ENERGY STUDY OF LAUNDRY FACILITIES

FORT KNOX, KENTUCKY

EXECUTIVE SUMMARY

DECEMBER, 1986

PREPARED FOR

DEPARTMENT OF THE ARMY

LOUISVILLE DISTRICT, CORPS OF ENGINEERS

CONTRACT NO. DACA 27-85-C-0125

Newcomb & Boyd

Consulting Engineers
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January 2, 1987

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Commander
U.S. Army Engineer District, Louisville
Attn: ORLED-M (Gerard Edelen)
P.O. Box 59
600 Federal Place, Room 667
Louisville, Kentucky 40201-0059

Re: Energy Survey of Laundry Facilities
Fort Knox, Kentucky
Contract No. DACA27-85-C-0125

Dear Mr. Edelen:

We are happy to enclose six (6) copies of our Final Submittal for the Energy Survey of the Fort Know Laundry Facility and revised Executive Summary. Please accept our apologies for the delay in getting these documents to you. We hope you will feel the thorough, coordinated presentation of information and funding documents is worth the wait.

The enclosed materials include a complete, bound revised Executive Summary and Report and Appendix sections for insertion in the notebooks supplied with the Prefinal Submittal. Those sections for replacement included in this submittal have been highlighted in yellow on the Table of Contents. Remove and discard the corresponding sections from your Prefinal Submittal Report and insert these revised sections.

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ENERGY STUDY OF LAUNDRY FACILITIES

FORT KNOX, KENTUCKY

REVISED EXECUTIVE SUMMARY
JULY, 1987

PREPARED FOR

DEPARTMENT OF THE ARMY

LOUISVILLE DISTRICT, CORPS OF ENGINEERS

CONTRACT NO. DACA 27-85-C-0125

NEWCOMB & BOYD CONSULTING ENGINEERS

ATLANTA, GEORGIA

FORT KNOX LAUNDRY ENERGY STUDY

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1.0 INTRODUCTION AND SUMMARY

1.1 Introduction:

This document is the Executive Summary of the Energy Survey of Laundry Facilities at Fort Knox, Kentucky. The purpose of this document is to briefly outline the existing and historical energy situation, summarize the methodology and results of the Energy Study, and present the specific energy conservation projects developed through the Energy Study.

This project is being performed under the direction of the Louisville District Corps of Engineers under Contract No. DACA 27-85-C-0125. The study is being performed by Newcomb & Boyd Consulting Engineers with home office in Atlanta, Georgia. Additional architectural assistance is provided by Louis & Henry, Architects of Louisville, Kentucky.

1.2 Fort Knox Laundry Facility:

The facility analyzed by this study consists of four (4) buildings located on Bullion Boulevard within Fort Knox Army Base (see Figure 1.1, Area Map, Figure 1.2, Site Map, Figure 1.3). Built in 1939 as temporary structures, each building and the equipment therein has undergone several renovations and modifications.

1.2.1 Building T-15 is a single story wood frame structure housing offices and classrooms used for the Fort Knox Driver's Education and Testing Program. Steam heat is provided via overhead piping from Building T-17.

1.2.2 Building T-16 is used as a general warehouse for parts and supplies for the laundry operation. The

office of the Director of Industrial Operations for the laundry is located at one end of this building also. Similar in size and construction to T-15, it also receives steam heat from Building T-17.

1.2.3 Building T-17 contains the central boiler plant for the 4 buildings of the laundry facility. Three Boilers, burning natural gas or No. 2 fuel oil, supply process steam to Building T-18 and heating steam for Buildings T-17, T-16 and T-15. Domestic hot water used by the laundry is heated by steam in this building and piped to T-18. Water softening equipment is also housed in T-17.

1.2.4 Building T-18 houses the actual laundry operation. Clothing from Army personnel, laundry from the Base hospital, and other items such as bedding, totalling over 5 million pieces annually, are sorted, washed, dried, ironed, folded, resorted, and shipped from this building. Additional offices, maintenance shop, toilets and breakrooms are also located in this building.

1.2.5 Detailed information on each building collected during the field survey is contained in Appendix A of the Energy Study report bound separately.

1.3 Objectives:

The objectives of the energy survey of the Fort Knox Laundry Facility as stated in the Scope of Work are:

1.3.1 Perform a complete energy audit and analysis of the laundry facilities.

1.3.2 Use and incorporate applicable data and results of related studies, past and current, including the Fort Knox EEAP Study.

1.3.3 Identify all Energy Conservation Opportunities (ECO's) including low/no cost items.

1.3.4 Perform an engineering and economic analysis of each ECO.

1.3.5 List and prioritize all ECO's based on Savings to Investment Ratio (SIR).

1.3.6 Prepare complete programming documentation for any Energy Conservation Investment Program (ECIP) projects.

1.3.7 Prepare implementation documentation for all projects identified for Quick Return on Investment Program (QRIP), OSD Productivity Investment Funding (OSD PIF), or Productivity Enhancing Capital Investment Program (PECIP) Funding.

1.3.8 Provide supporting information to facilitate the implementation of Low/No Cost projects.

1.3.9 Prepare a comprehensive report which will document the work accomplished, the results and recommendations.

A complete copy of the Scope of Work for the project is included in Appendix E of the Energy Study Report.

1.4 Project Scope:

The energy audit and resulting engineering analysis of the Fort Knox Laundry Facilities includes four buildings, (T-15, T-16, T-17 and T-18) and their utility systems. Analysis of a building includes not only the building's envelope and mechanical and electrical systems, but also occupancy, operating schedules, and usage. Processes conducted in a building are closely scrutinized for potential energy conservation opportunities.

1.5 Executive Summary Scope:

This report provides a summary of the energy and cost analysis leading to recommendation of proposed energy conservation projects documented in the Energy Report. The Energy Report's prime objective is to use the data gathered during site visits and field inspections to select, analyze savings, estimate cost and evaluate economic criteria for energy conservation opportunities. Section 2.0 of this report provides illustration of the existing energy situation at each site based on the available information provided by the Community. Energy conservation opportunities (ECOs) considered for selection are summarized in Section 3.0 of this report. These ECO's are derived from the Army Facilities Energy Plan, installation suggestions, and experience on other projects. Section 4.0 of this Executive Summary briefly describes the various energy conservation projects developed as a result of our analysis. Three types of projects were identified including an ECIP project, two PECIP projects, and two additional projects composed of ECO's with SIR's greater than 1.0 that do not qualify for available funding programs.

Section 5.0 of this Summary addresses the impact on energy consumption of implementing the various energy conservation project.

1.6 Energy Study Methodology:

1.6.1 Objectives: The primary end product of the Interim Submittal was a consolidated list of architectural, mechanical, and electrical modification projects which will result in a reduction of energy consumption. As part of the Prefinal Submittal, this list was honed through review comments. During this process of review, Facility and Corps of Engineers personnel selected ECO's to be grouped into energy conservation projects. Funding documents have been prepared for those selected projects as a part of the Prefinal Submittal. A list of these projects is contained in Section 4.0 of this report.

1.6.2 Methodology: The analysis was accomplished by following these basic steps:

Step 1 - Prepare a master list of energy conservation opportunities (ECO) for buildings and utility systems based on field survey experience and the list of ECOs included in Scope of Work.

Step 2 - For each building and utility system, select those ECOs from the master list which are applicable according to the survey data.

Step 3 - Calculate energy savings for each ECO/building/system combination. The calculation process uses a combination of computerized and manual methods. Manual methods are used where the ECOs are simple and are not affected by other ECOs. Computer analysis is used for building ECOs where many interrelated factors affect the results. The computer analysis consists of a base-line and modified analysis. The base-line run is based on existing conditions and operations. Subsequent runs simulate performance after the energy conservation project under study is implemented. The difference between those runs are the savings estimated for that ECO.

Step 4 - Calculate the cost to implement each ECO selected for each building. Costs have been developed from manufacturer's quotes, contracting experience, and the Means Cost Estimating Guides. All costs in the analysis are based on FY86 award. In preparing specific project documentation, the cost is escalated to the midpoint of construction.

Step 5 - Based on the savings and cost identified in Steps 3 and 4, economic analysis as defined in ECIP criteria is performed. Economic parameters include Total Discounted Savings, and SIR. These are summarized in a table and listed in order based on SIR.

Step 6 - Suggested packaging schemes for combining individual ECOs for individual buildings into projects are prepared following the Interim Submittal Presentation. These packaging schemes are reviewed by installation personnel and returned with comments.

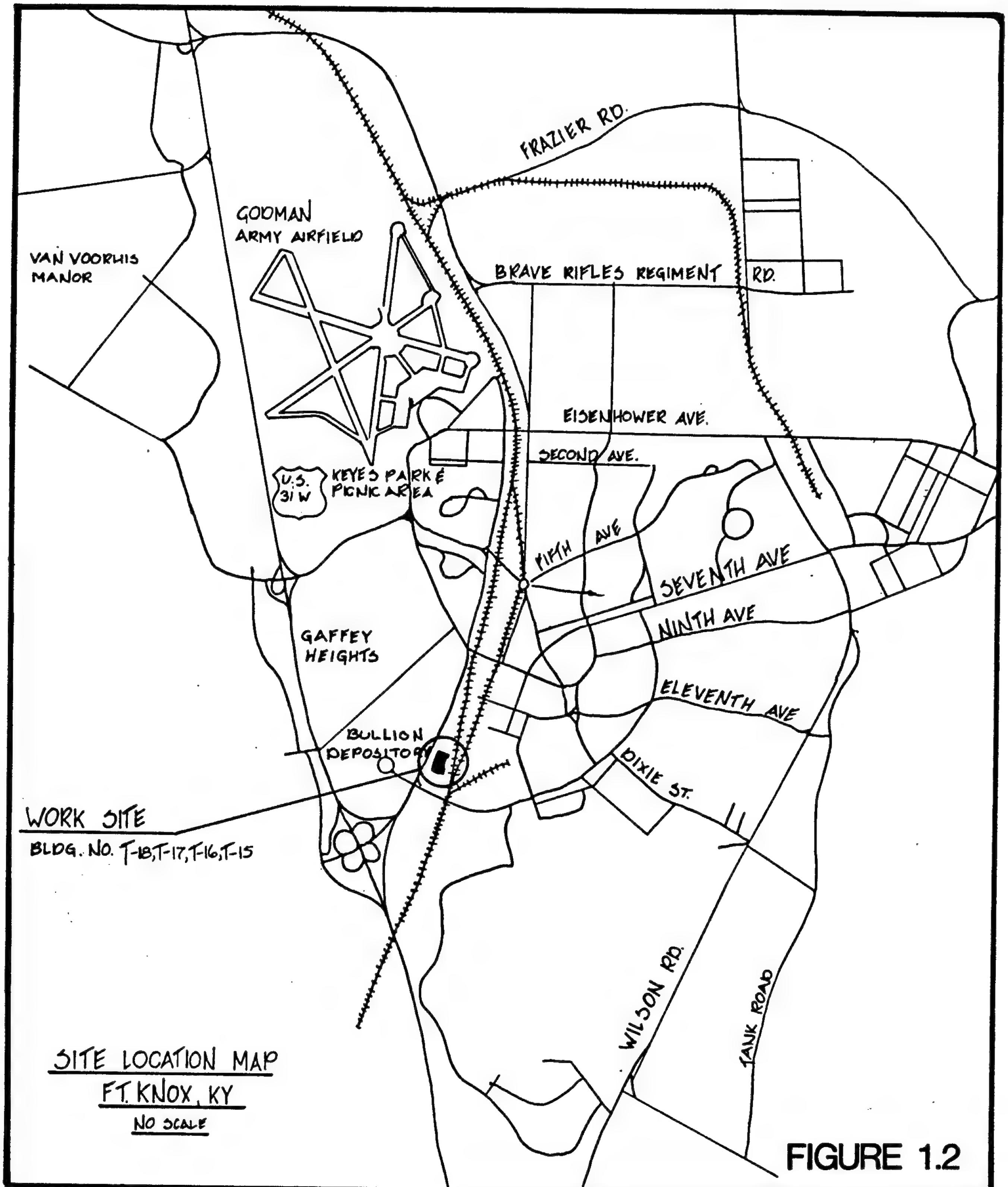
Step 7 - Using comments received on the Interim Submittal and proposed packaging schemes, ECO's and their associated economic calculations are updated.

Step 8 - Programming and implementation documentation on each energy conservation project is prepared. Documents are prepared using criteria furnished at the project's inception according to the type of funding source (ECIP, QRIP, OSD-PIF, PECIP or No/Low Cost).

FIGURE 1.1

Buildings Included in Energy Study

BLDG. NO.	BLDG. NAME	GROSS SQ. FT.
T-15	Driver's Education	9,000
T-16	Warehouse	9,000
T-17	Central Boiler Plant	5,166
T-18	Laundry	49,554



SITE LOCATION MAP
FT. KNOX, KY
NO SCALE

FIGURE 1.2

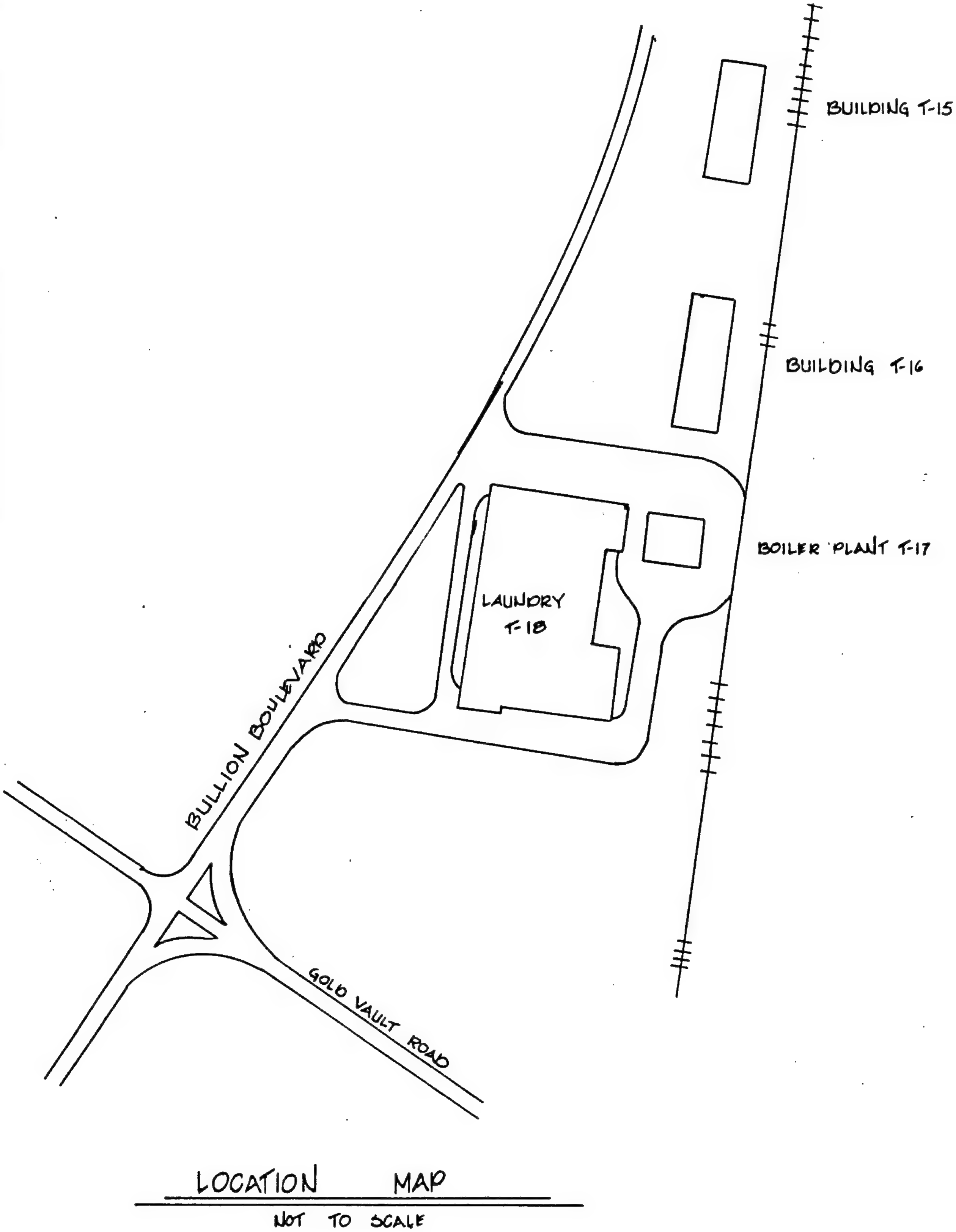

BUILDING T-15
BUILDING T-16
BOILER PLANT T-17
LAUNDRY T-18
BULLION BOULEVARD
GOLD VAULT ROAD
LOCATION MAP
NOT TO SCALE

FIGURE 1.3

2.0 EXISTING ENERGY SITUATION

2.1 Background:

As part of the energy study for the Laundry Facility, past and present energy consumption was examined.

An examination of the existing energy situation can provide an indication of the relative importance of each type or component of energy consumption. By comparing how much energy is used for heating vs. the consumption for domestic water heating for example, the study may establish priorities for those items which have the greatest potential for energy savings. One difficulty which arises in performing this type of analysis is the general lack of sub-metering data of a particular installation's energy consumption. Since most Army facilities were constructed during a time when energy costs were relatively unimportant, very little emphasis in the past has been placed on actual metering of energy usage for a particular function. For example, it's impossible in most cases to examine actual metered data of individual building's energy consumption within a facility or the usage of energy for different activities within a building. Since this metered data is not available, engineering estimates have to be made to determine the data.

2.2 General Description:

The buildings of the laundry facility utilize electricity supplied by Fort Knox which, in turn, purchases the electricity from a local electric utility. The price of electricity is generally composed of charges for kilowatt-hour (KWH) consumption and kilowatt (KW) demand. While Fort Knox has this type of billing structure, the

installation furnished an average total cost per kilowatt-hour to use in the evaluation of ECO's.

Electricity is utilized for a variety of tasks including lighting, operation of heating system distribution equipment and office equipment. Laundry processors, including washing, drying, ironing, and sorting clothing also consume electricity.

Fossil fuels including No. 2 oil and natural gas are consumed by the central boiler plant in Building T-17 to produce steam. This steam is then utilized for space heating, domestic hot water heating and direct process applications in the laundry.

2.3 Energy Consumption Components:

As discussed earlier, no detailed sub-metering data is available for the sites to provide a break down of energy consumption by component. Computer modeling and engineering estimating techniques have been used to assess constituent energy consumption.

2.4 Distribution Systems Analysis:

2.4.1 Steam System:

Steam produced in the central boiler plant, Building T-17, is used within Building T-17 and piped to Buildings T-15, T-16 and T-18.

Within Building T-17 steam at 100 psi is used for space heating and to produce domestic hot water used in Building T-18. Much of the insulation on the steam and condensate piping in T-17 is damaged. Leaks in the condensate system are numerous. The steam heat exchangers and associated

piping for the domestic hot water generators have several significant steam and condensate leaks. A condensate cooler, or heat exchanger designed to preheat domestic hot water from returning condensate is in use, but damaged insulation, leaks, and irregular water flow through the unit limit its effectiveness. The boilers themselves are in excellent condition and are well maintained. However, calibration of controls, additional insulation and repair of the feedwater heater offer significant potential for energy savings.

Buildings T-15 and T-16 are supplied steam at 20 psig for space heating. Overhead steam distribution piping from T-17 to T-16 and from T-16 to T-15 is in fair condition. Steam distribution piping run inside the building, however, is uninsulated. This is particularly a problem in the warehouse portion of T-16 which is only minimally heated. Building occupants report many problems with the existing heating systems. Due in part to the uninsulated piping, large quantities of condensate accumulate at the unit heaters and drastically reduce their heat output. Steam traps and condensate return systems seem unable to handle the condensate quantities encountered at building start-up. The condensate return system in T-16 is malfunctioning and T-15 has no condensate receiver and return pump. Condensate from these two buildings flows to a common header with condensate returned from T-17 and T-18. However, because T-17 and T-18 operate at a higher steam pressure of 100 psig than the 20 psig pressure of T-15 and T-16, condensate return from T-15 and T-16 is ineffectual without a properly functioning pressure condensate feed system.

Building T-18 operates on 100 psig steam from T-17. This steam is used for space heating, to heat irons, presses and dryers, and for direct injection to washers. Pipe

insulation is in moderate to good condition. Original asbestos insulation is being incapsulated at this time to reduce the health hazard. As new equipment has been added and piping altered to accommodate it, pipes have been insulated with fiberglass which is in good condition. Because the space heating system is fed from the same steam main, equipment remains hot as long as steam pressure is maintained for the heating system. This lack of control results in energy waste.

2.4.2 Electrical System:

Each building in the laundry facility complex is separately fed electricity from overhead power lines. Buildings T-15, T-16 and T-17 are served from pole mounted transformers. Building T-18 is served through its own transformer vault located on the east side of the building. Distribution system within the buildings are antiquated, but generally adequate for the required service. Building T-18's wiring has been renovated in piecemeal fashion as new equipment has been added.

2.5 Utility Metering:

2.5.1 Electricity:

Fort Knox is metered and billed for electricity as a single entity. No separate metering of service to individual activities, such as the laundry, is in use. At the present time, the Contractor running the laundry facility is not directly billed for energy. An estimate of energy costs is taken into account when determining the laundry service cost. Contractors then bid competitively to set the contract price at which services will be provided. We recommend the installation of a separate electric meter for Building T-18 and a system of equitably passing the

utility costs to the Contractor. Economics can be a strong motivation for energy conservation.

2.5.2 Fuels:

Records of monthly oil and natural gas usage are recorded for the boiler plant. Natural gas has been used almost exclusively for the past 5 years. There are some questions as to the accuracy of the natural gas meter. Natural gas consumption does not correlate well with records of steam production, boiler plant operating hours, and make-up water consumption. Testing and calibration of all metering devices is recommended.

2.6 Electrical Energy:

2.6.1 Data on electrical energy consumption and demand is not available for the site. No separate submetering exists from which this information could be obtained. Engineering estimates of average consumption for each building were prepared. These are shown in Figure 2.1.

2.6.2 The total cost of electricity is generally composed of charges for kilowatt-hour (KWH) consumption, kilowatt (KW) demand, and power factor connection. While Fort Knox has this type of billing structure, we were furnished an average cost of electricity in dollar per kilowatt-hour for use in our analysis. See Figure 2.2. This value was calculated by taking the total cost for electricity, including charges for energy, demand, and power factor, and dividing it by the total number of kilowatt-hours used.

While this method provides an acceptable answer, it does not permit the evaluation of the cost savings potential of ECO's that reduce electrical demand.

2.7 Fuels:

2.7.1 The central boiler plant in Building T-17 has the capability of burning either No. 2 fuel oil or natural gas. While natural gas has been used for the past 5 years, complete records of fuel consumption were obtained for the past 4 years only. Natural gas consumption data is presented in Figure 2.3 in tabular form and in Figures 2.4 through 2.7 graphically. Steam production data for the same period is included for comparison. See Figures 2.8 through 2.13.

2.7.2 Fuel prices were supplied by the Corps of Engineers at the project's inception. These prices are shown in Figure 2.2.

2.7.3 No separate submetering of energy consumed in each building exists. Engineering estimates and computer based energy consumption modeling programs were used to calculate energy consumption by type of use and fuel source. Refer to Figure 2.1.

2.8 Total Energy Consumption:

Using the same engineering estimates and computer based energy consumption modeling programs used for the determination of fuel consumption in each building, the average annual energy consumption of each building was also calculated. See Figure 2.1.

2.9 Energy Consumption Analysis:

Examining these graphs and figures, several trends become evident. Natural gas and steam consumption peak during winter months. However, because of the high process loads, it is necessary to compare these consumption figures to laundry production for the same time period. Quarterly laundry output for the past 3 years is shown in tabularly in Figure 2.14 and graphically in Figures 2.15 through 2.17. This data reveals that production and, correspondingly, process energy demand peaks during the summer months. Consequently, because of the winter peaking gas consumption, we may infer that space heater is a major energy consumer and conservation efforts should be directed accordingly.

Comparing fuel consumption, one year to the next, we see a comparatively small change in energy consumption over the past 3 years. However, a disparity in natural gas consumption data exists between 1982 and the following three years, 1983, 1984, and 1985. A check of steam records shows little difference in steam production over the past four years. This further suggests a possible error in the meter's calibration. Similar comments on electrical consumption cannot be made for lack of historical data.

2.10 Summary:

Clearly, the process energy requirements of a laundry for domestic hot water, drying and finishing clothing and driving machinery is the prime consumer of energy.

Through the examination of historic energy consumption data, it is evident that space heating and its associated auxiliary loads are also a major energy user. Energy conservation efforts directed at reducing heat loss

through building envelope modification and improving heating system efficiency offer great potential for savings as illustrated in this report. Other key areas for energy conservation include improvements in process efficiency and waste heat recovery.

FIGURE 2.1

Building Energy Budgets

T-15 Driver's Education Building

Heating	825.4×10^6 BTU/Yr.	(Natural Gas)
Auxiliary	182.1×10^6 BTU/Yr.	(Electricity)
Lights & Equip	115.0×10^6 BTU/Yr.	(Electricity)
TOTAL	1.123×10^9 BTU/Yr.	
	124.7×10^3 BTU/Yr. - Sq. Ft.	

T-16 Warehouse

Heating	774.5×10^6 BTU/Yr.	(Natural Gas)
Auxiliary	140.1×10^6 BTU/Yr.	(Electricity)
Lights & Equip	56.85×10^6 BTU/Yr.	(Electricity)
TOTAL	971.5×10^6 BTU/Yr.	
	107.9×10^3 BTU/Yr. - Sq. Ft.	

T-17 Boiler Plant

Heating	637.7×10^6 BTU/Yr.	
Auxiliary	205.8×10^6 BTU/Yr.	
Lights & Equip	500.1×10^6 BTU/Yr.	(Electricity)
TOTAL	1.344×10^9 BTU/Yr.	
	260.2×10^3 BTU/Yr. - Sq. Ft.	

FIGURE 2.1 (continued)

Building Energy Budgets

T-18 Laundry

Heating	2.379×10^9	BTU/Yr.	(Natural Gas)
Auxiliary	692.9×10^6	BTU/Yr.	(Electricity)
Lights & Equip	876.2×10^6	BTU/Yr.	(Electricity)
Domestic Hot Wtr	6.089×10^9	BTU/Yr.	(Natural Gas)
Process Heating	11.01×10^9	BTU/Yr.	(Natural Gas)
Process Electricity	3.435×10^9	BTU/Yr.	(Electricity)
TOTAL	24.48×10^9	BTU/Yr.	
	494.0×10^3	BTU/Yr. - Sq. Ft.	

FIGURE 2.2

Energy Costs

	Purchase Price [1]	Equivalent Cost [2]
Electricity	$.041/KWH	$3.53/MBTU
Natural Gas	$4.37/MCF	$4.24/MBTU
Number 2 Fuel Oil	$1.03/GAL	$7.43/MBTU
Coal	$38.35/TON	$1.56/MBTU
LP Gas	$.77/GAL	$8.11/MBTU

1) Fuel and electricity purchase price provided by Louisville District Corps of Engineers based on current Energy Costs at Fort Knox, Kentucky at the time of this study.

2) Equivalent energy costs calculated using purchase price and energy conversion factors below from ECIP Guidance dated 4 March 1985 by DAEN-ZCP-U.

Conversions

1 KWH Electricity (Source)	=	11,600 BTU
1 CF Nat. Gas	=	1,031 BTU
1 Gal. No. 2 Oil	=	138,700 BTU
1 Ton Coal	=	24.58 MBTU
1 Gal. L.P. Gas	=	95,000 BTU

FIGURE 2.3 NATURAL GAS CONSUMPTION

	1982	1983	1984	1985
JAN	NO DATA	560,500 MCF	595,400 MCF	644,000 MCF
FEB	227,871 MCF	492,900	465,700	583,600
MAR	196,473	458,600	466,700	400,400
APR	149,565	361,000	339,700	368,300
MAY	107,812	315,000	353,900	391,200
JUN	126,111	297,200	306.200	363,300
JUL	108,978	274,100	333,700	359,100
AUG	126,730	307,100	341,200	354,200
SEP	123,441	296,200	262,300	265,300
OCT	NO DATA	319,300	324,100	309,300
NOV	202,516	374,900	386,900	300,880
DEC	155,550	524,700	353,400	
TOTAL		4,581,500 MCF	4,529,200 MCF	

FIGURE 2.4
1982 NATURAL GAS CONSUMPTION

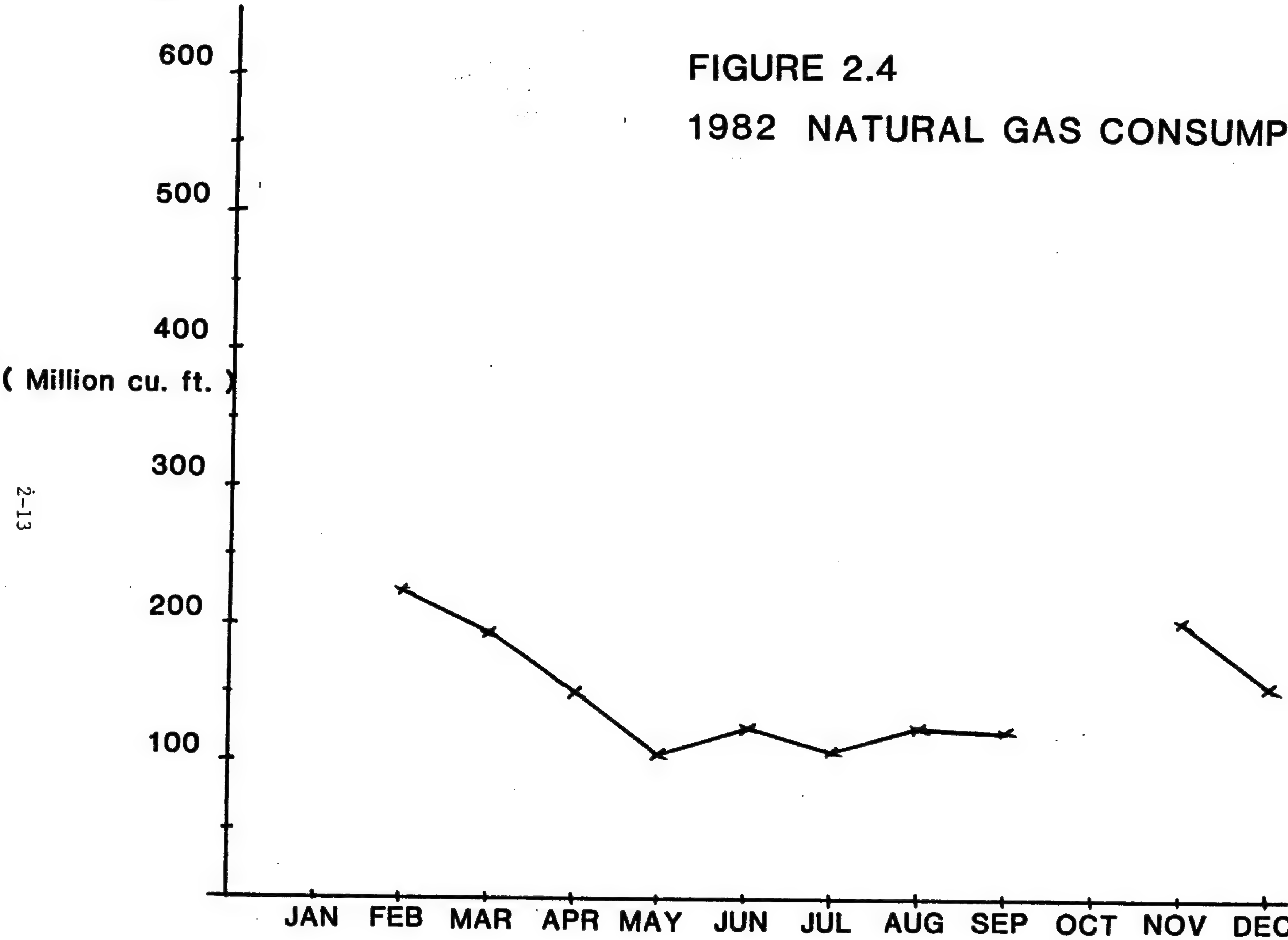
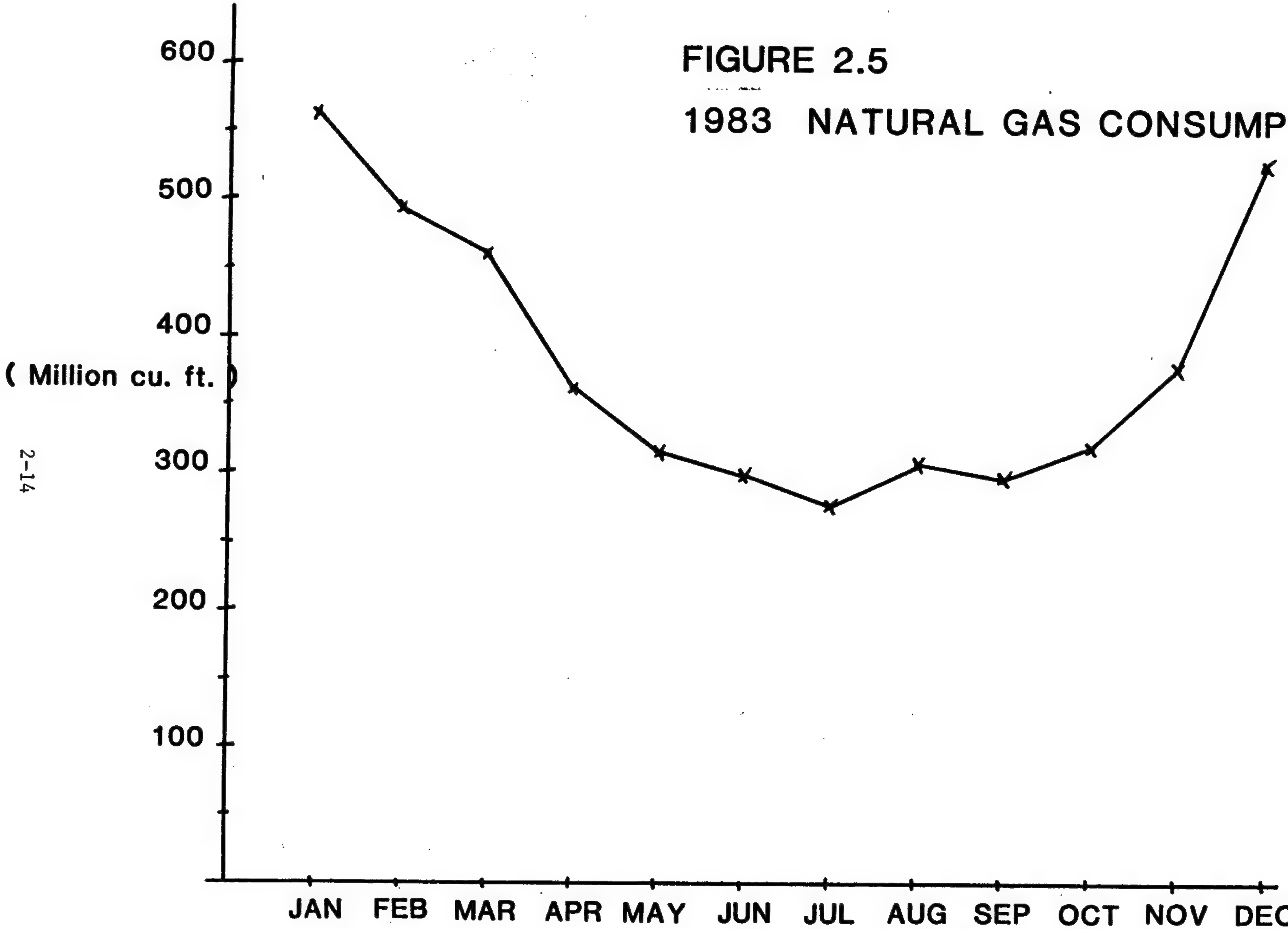


FIGURE 2.5

1983 NATURAL GAS CONSUMPTION



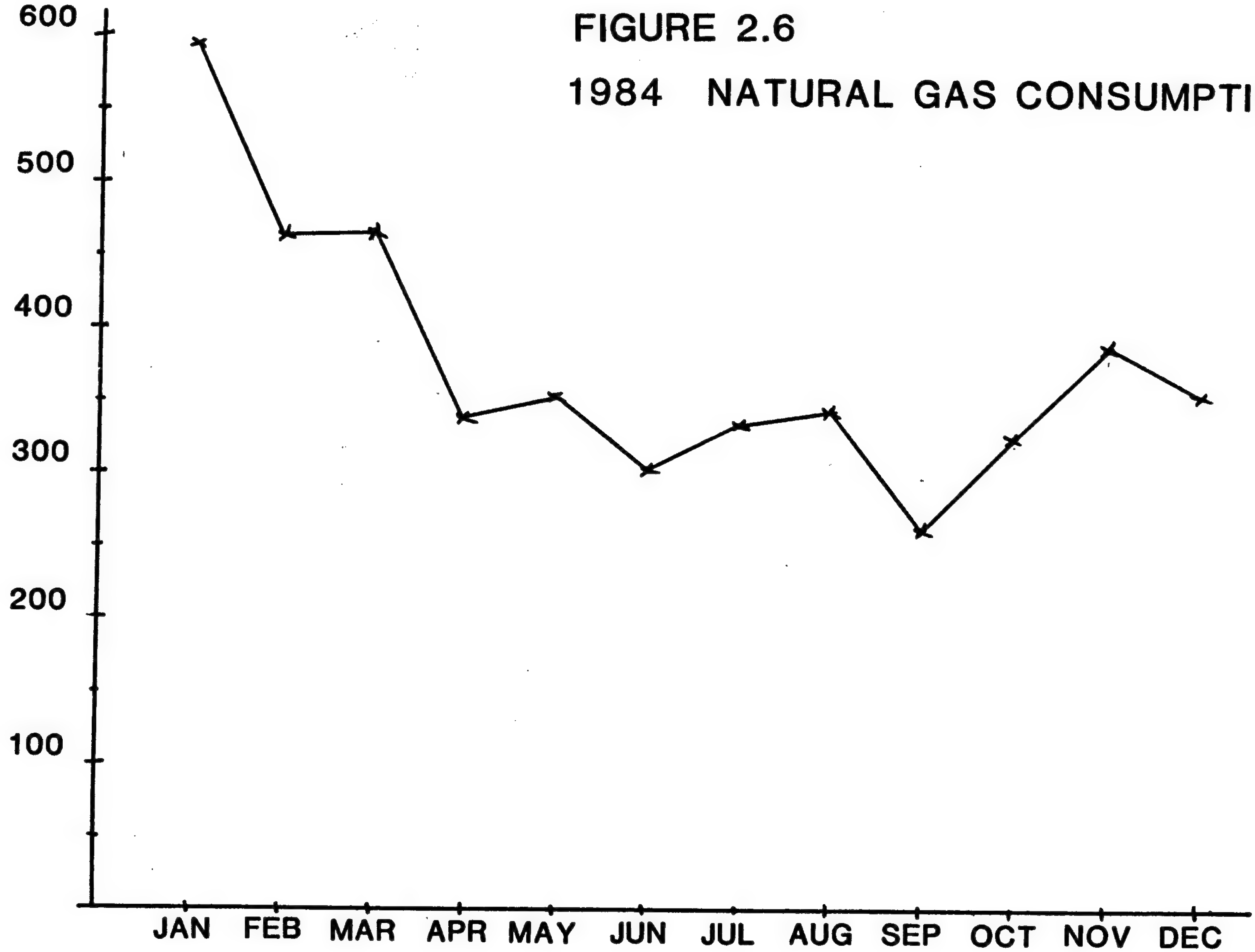


FIGURE 2.6

1984 NATURAL GAS CONSUMPTION

FIGURE 2.7

1985 NATURAL GAS CONSUMPTION

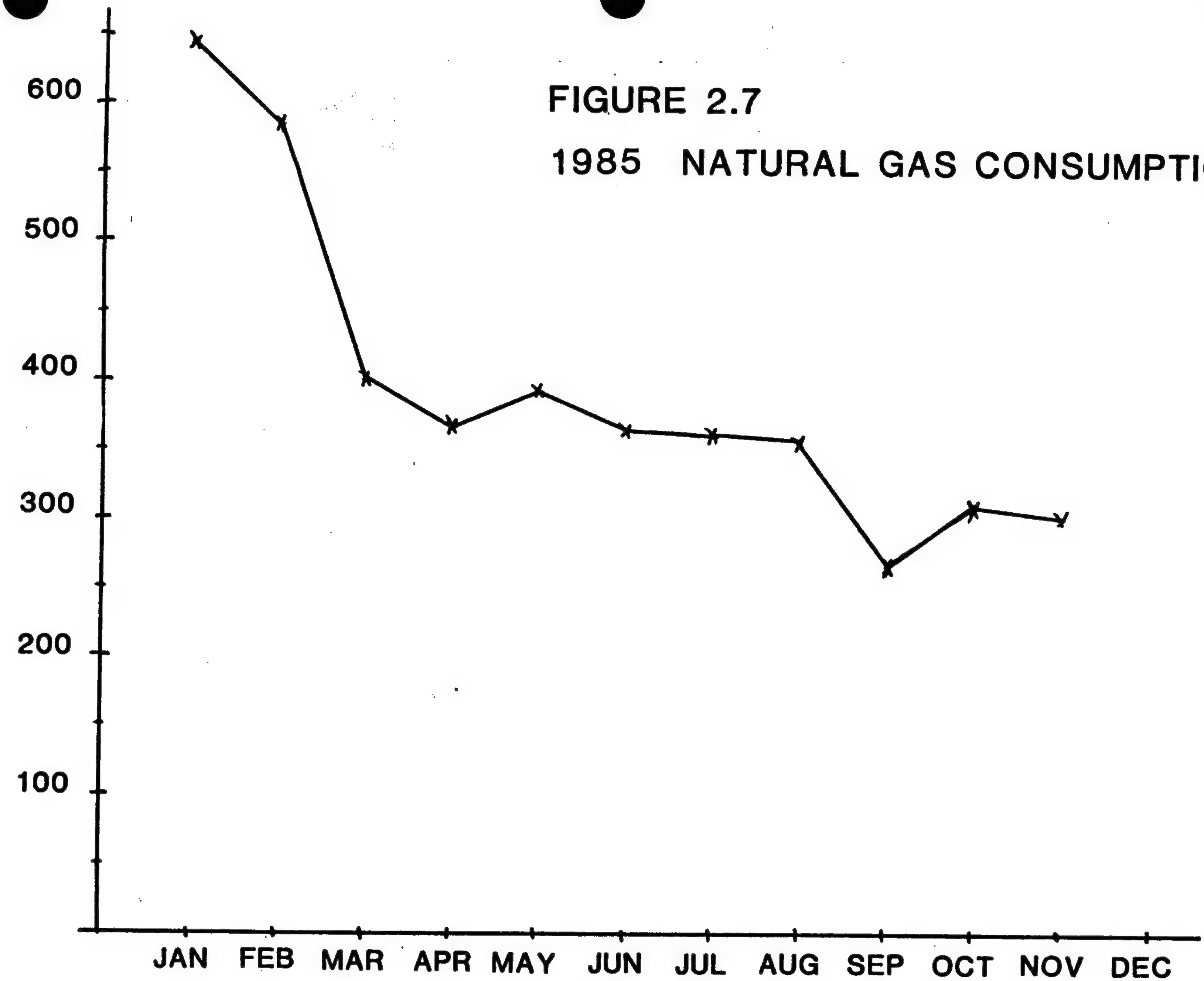


FIGURE 2.8 STEAM PRODUCTION

	1982	1983	1984	1985
JAN	3497×10^3 lb.	3487×10^3 lb.	2572×10^3 lb.	2121×10^3 lb.
FEB	3576×10^3	2447×10^3	2668×10^3	2175×10^3
MAR	3089×10^3	2976×10^3	3095×10^3	2329×10^3
APR	2144×10^3	2647×10^3	2785×10^3	2320×10^3
MAY	2096×10^3	2495×10^3	2940×10^3	2399×10^3
JUN	1337×10^3	1945×10^3	2423×10^3	1763×10^3
JUL	NO DATA	1971×10^3	2354×10^3	1957×10^3
AUG	1312×10^3	1770×10^3	2482×10^3	1865×10^3
SEP	1795×10^3	2320×10^3	1480×10^3	1470×10^3
OCT	3531×10^3	2688×10^3	1721×10^3	1560×10^3
NOV	4294×10^3	2187×10^3	2389×10^3	1909×10^3
DEC	3320×10^3	2782×10^3	2033×10^3	
TOTAL		29.715×10^6 lbs.	28.892×10^6 lbs.	

FIGURE 2.9
1981 STEAM PRODUCTION

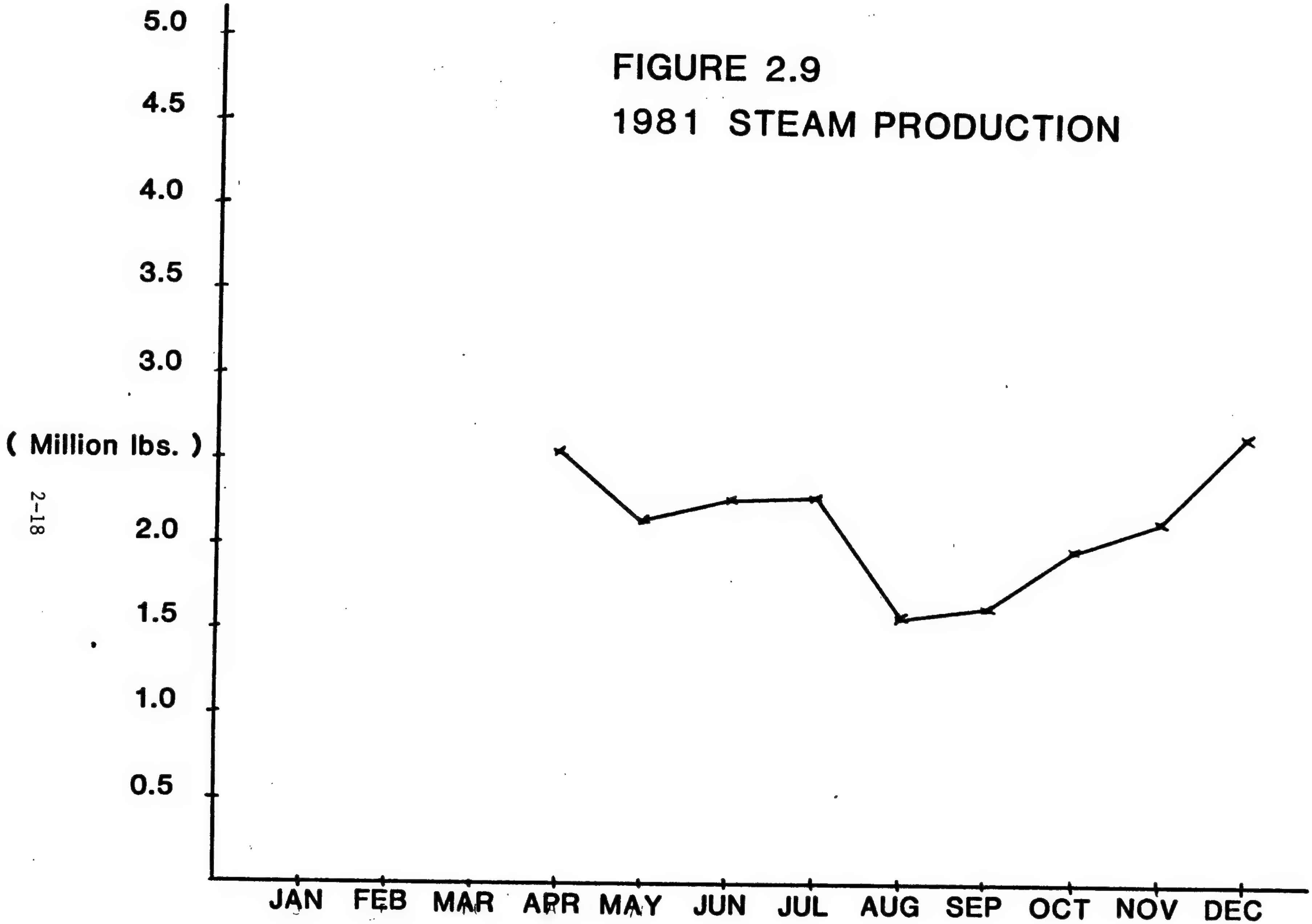


FIGURE 2.10

1982 STEAM PRODUCTION

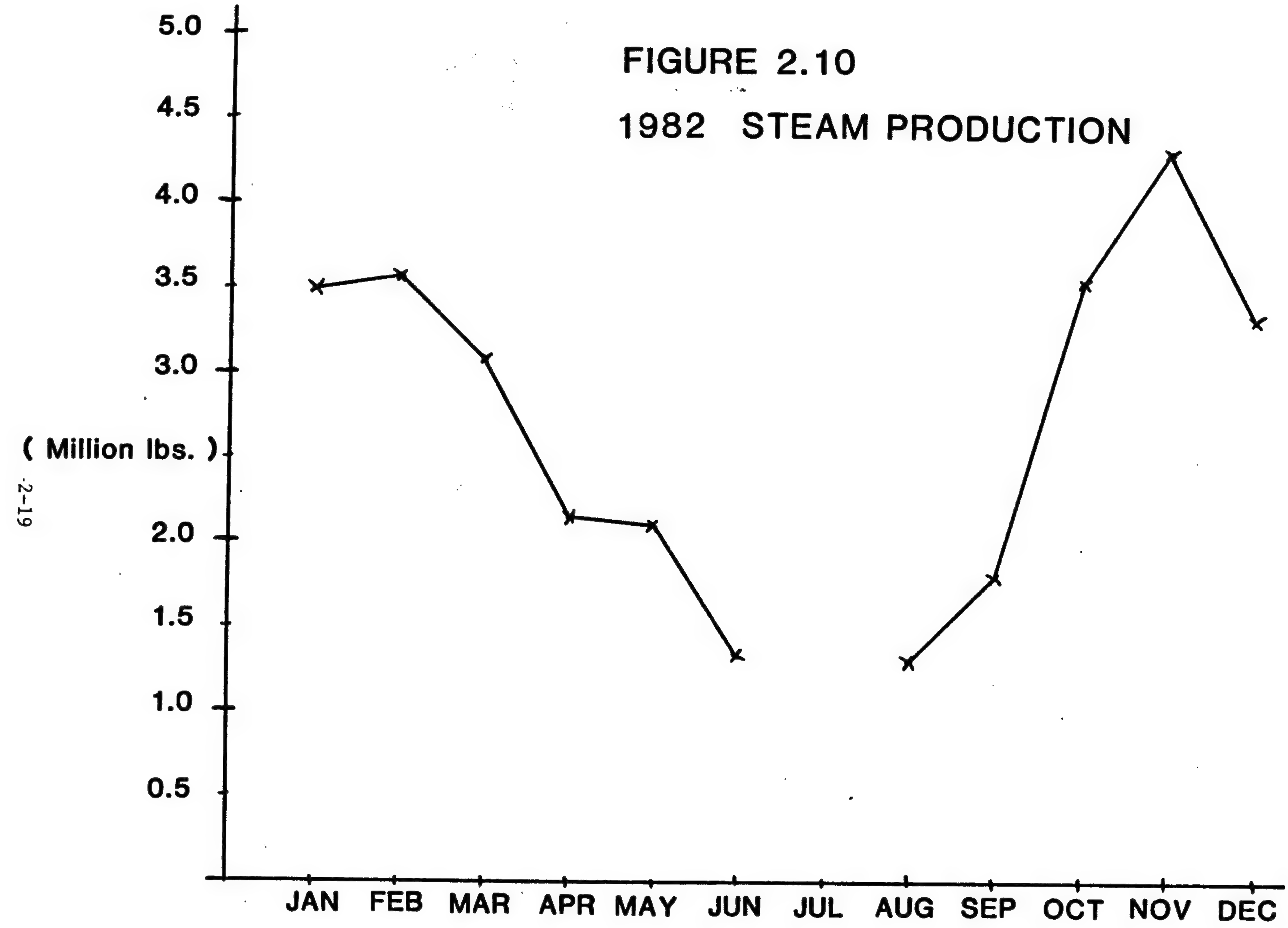


FIGURE 2.11

1983 STEAM PRODUCTION

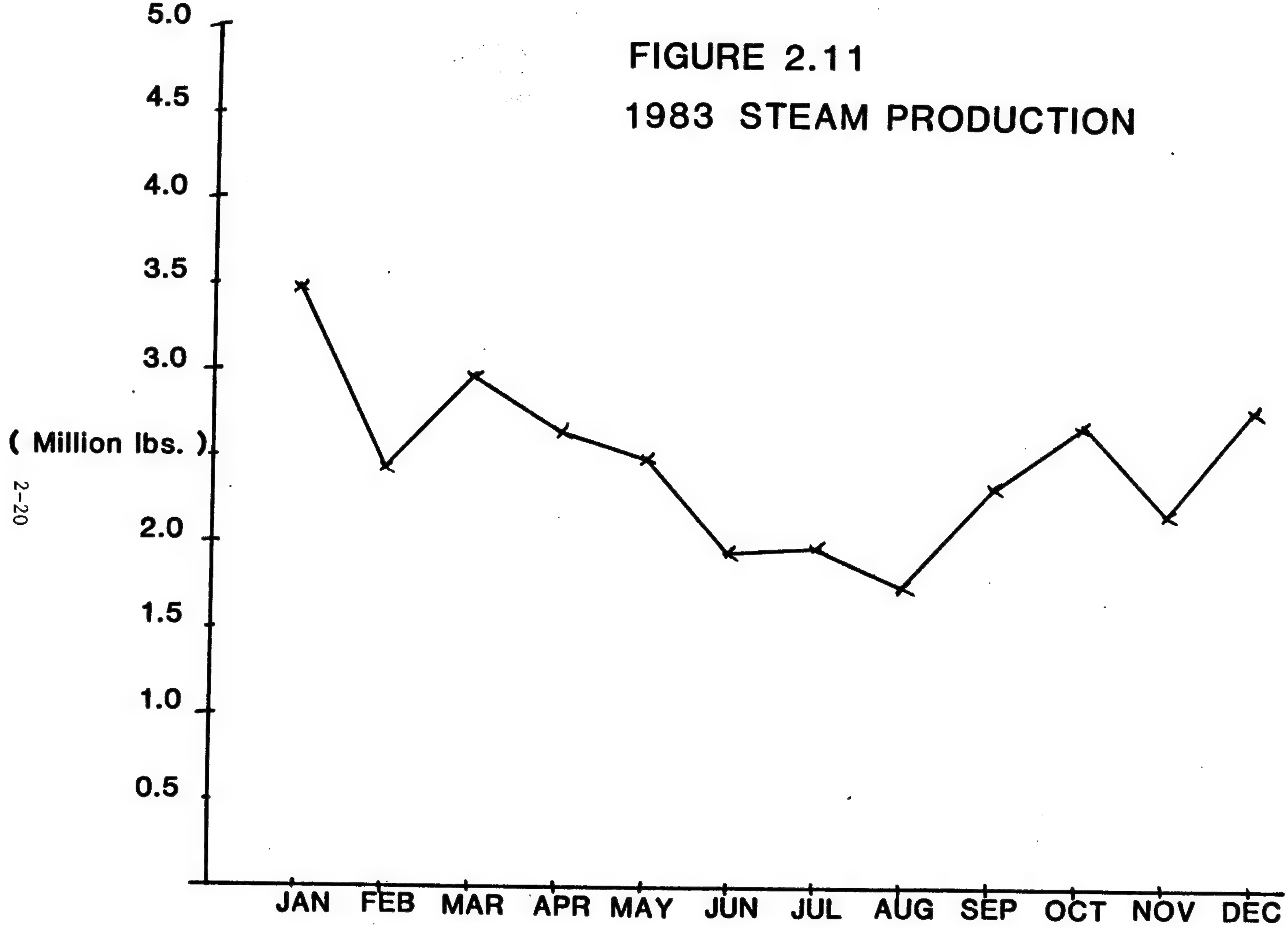


FIGURE 2.12

1984 STEAM PRODUCTION

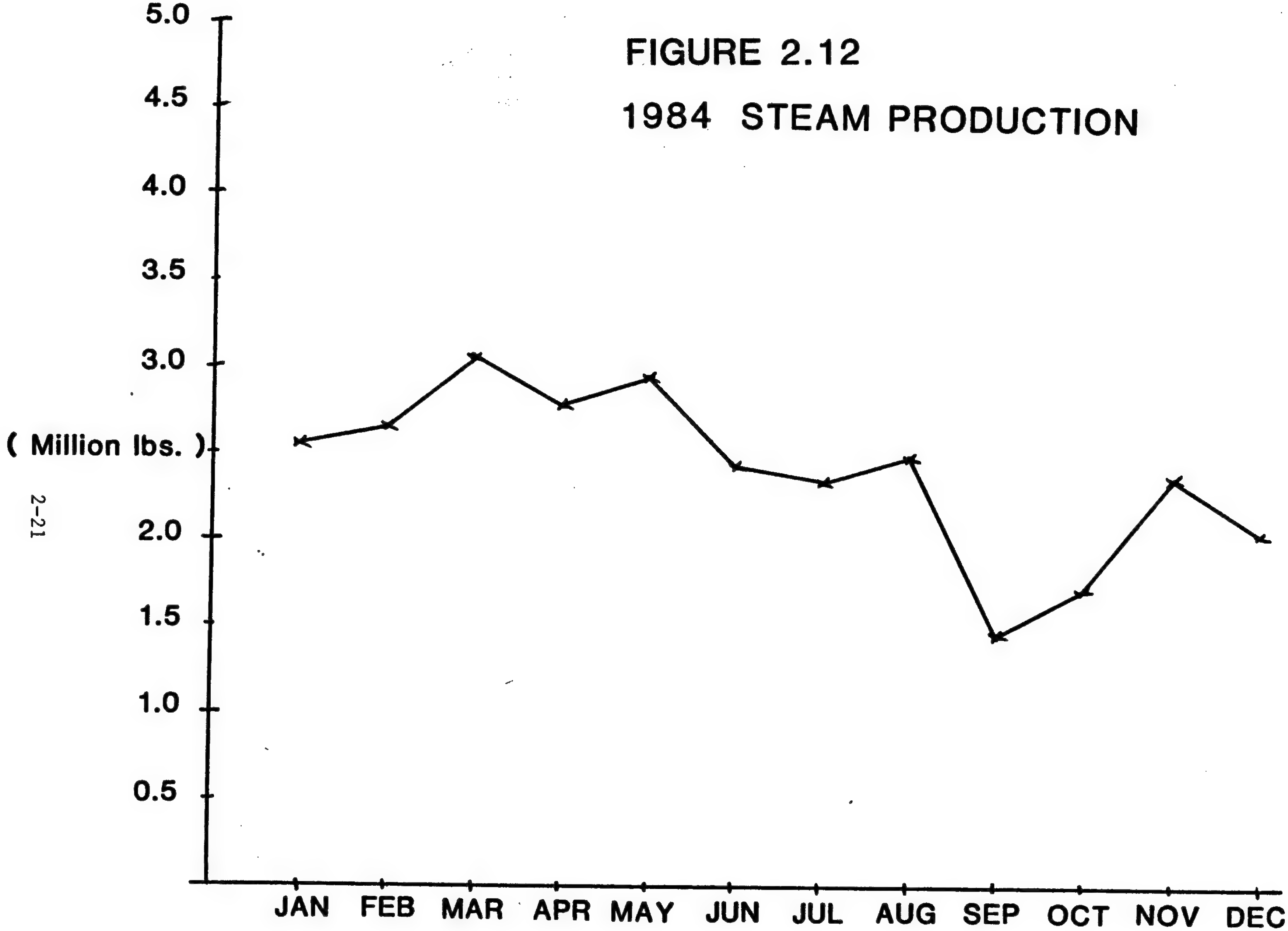


FIGURE 2.13

1985 STEAM PRODUCTION

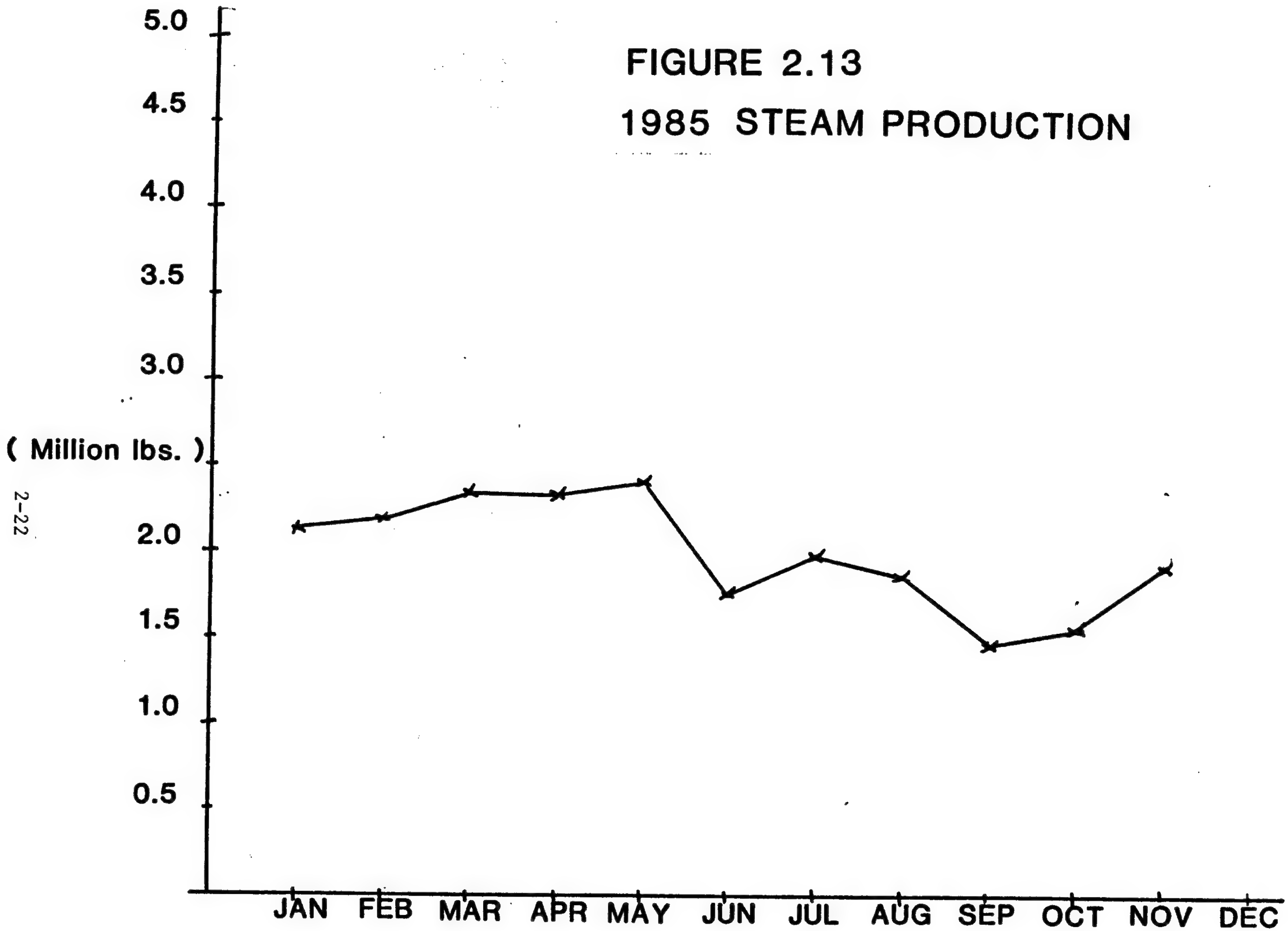


FIGURE 2.14 LAUNDRY PRODUCTION DATA

	FY 82	FY 83	FY 84	FY 85
FIRST QUARTER		1,155,939 PIECES	1,211,800 PIECES	1,134,867 PIECES
SECOND QUARTER		1,337,560 PIECES	1,288,469 PIECES	1,227,111 PIECES
THIRD QUARTER		1,426,301 PIECES	1,415,495 PIECES	1,287,971 PIECES
FOURTH QUARTER		1,543,082 PIECES	1,432,569 PIECES	1,379,440 PIECES
TOTAL		5,462,882	5,348,333	5,029,389

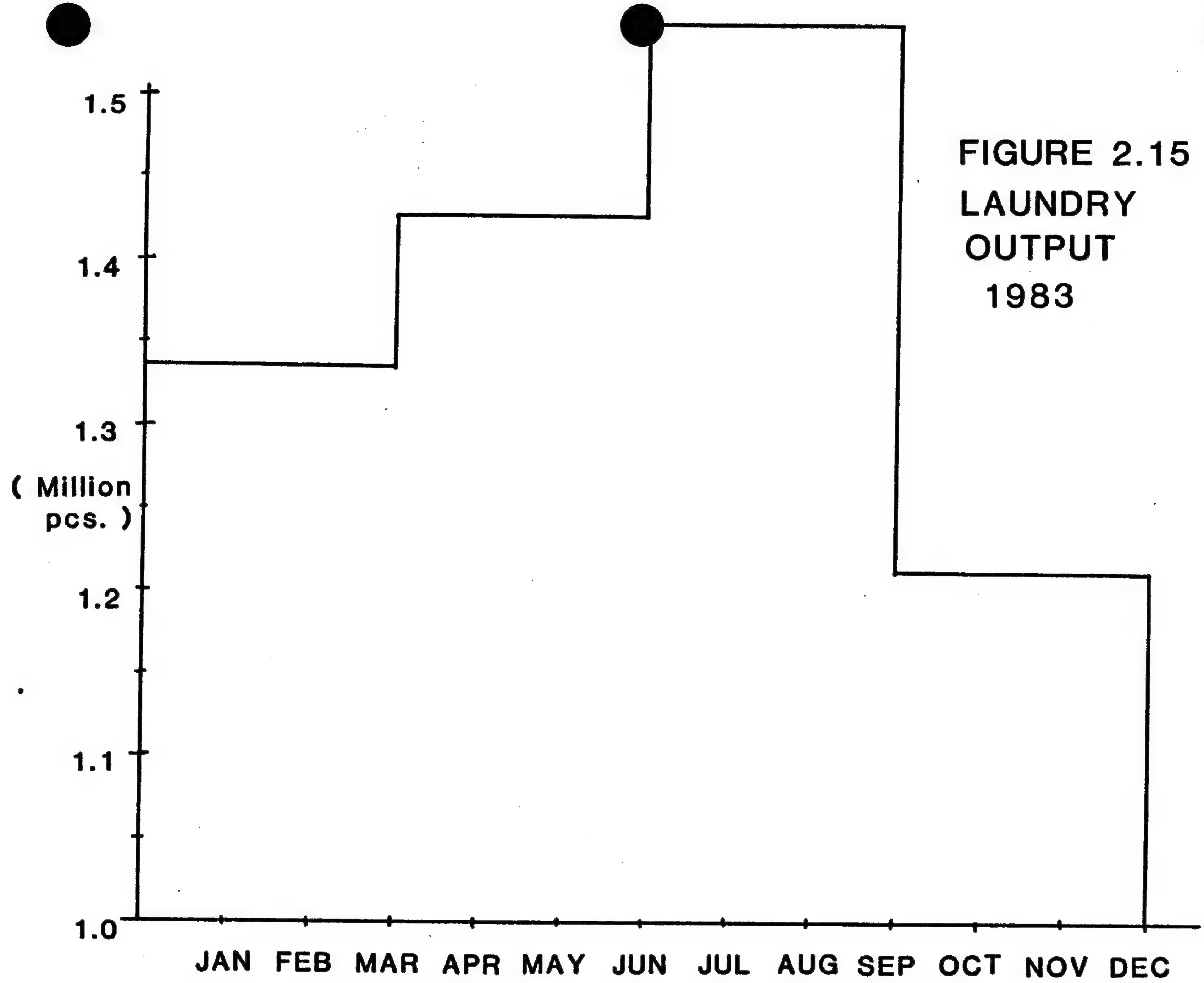


FIGURE 2.15
LAUNDRY
OUTPUT
1983

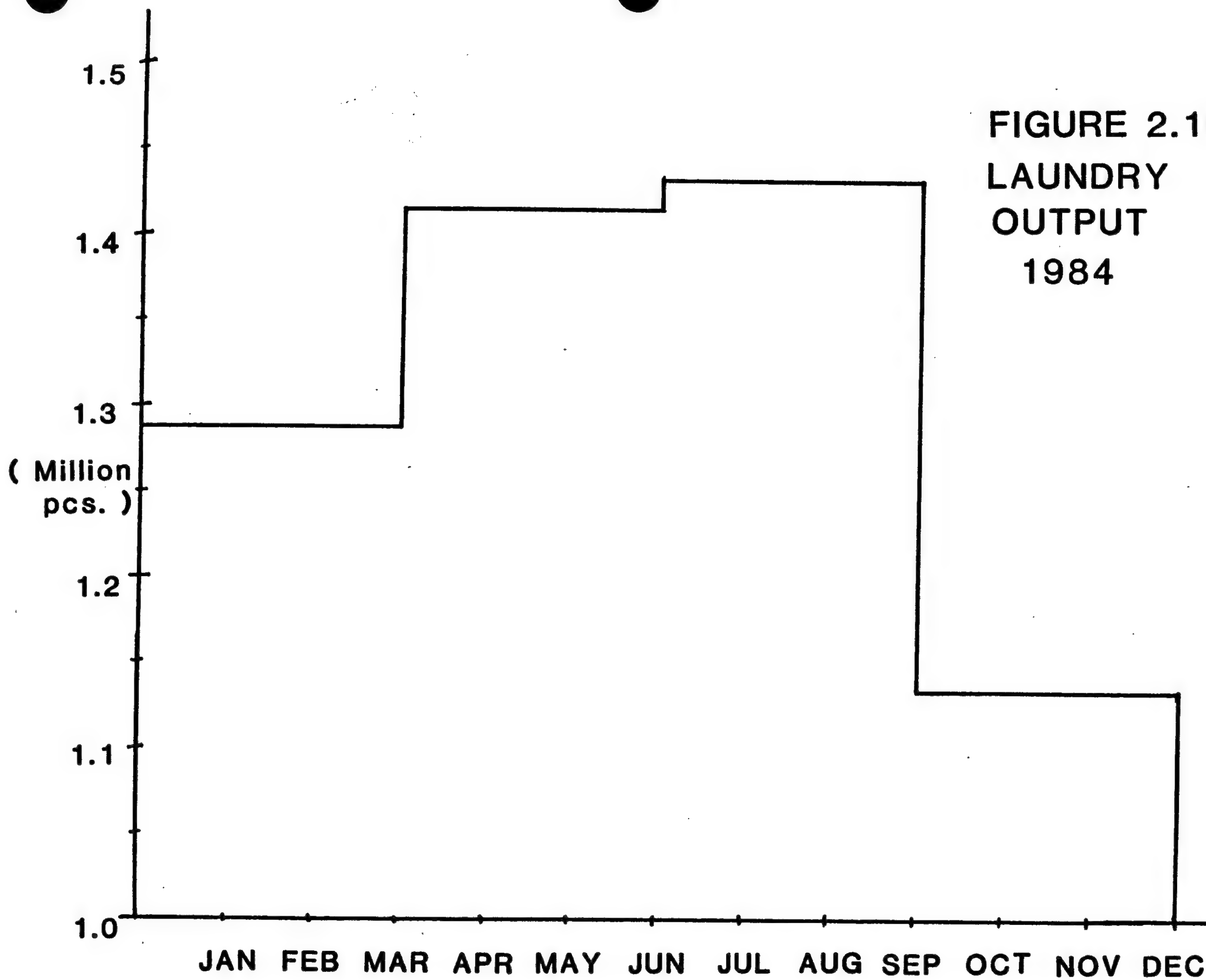
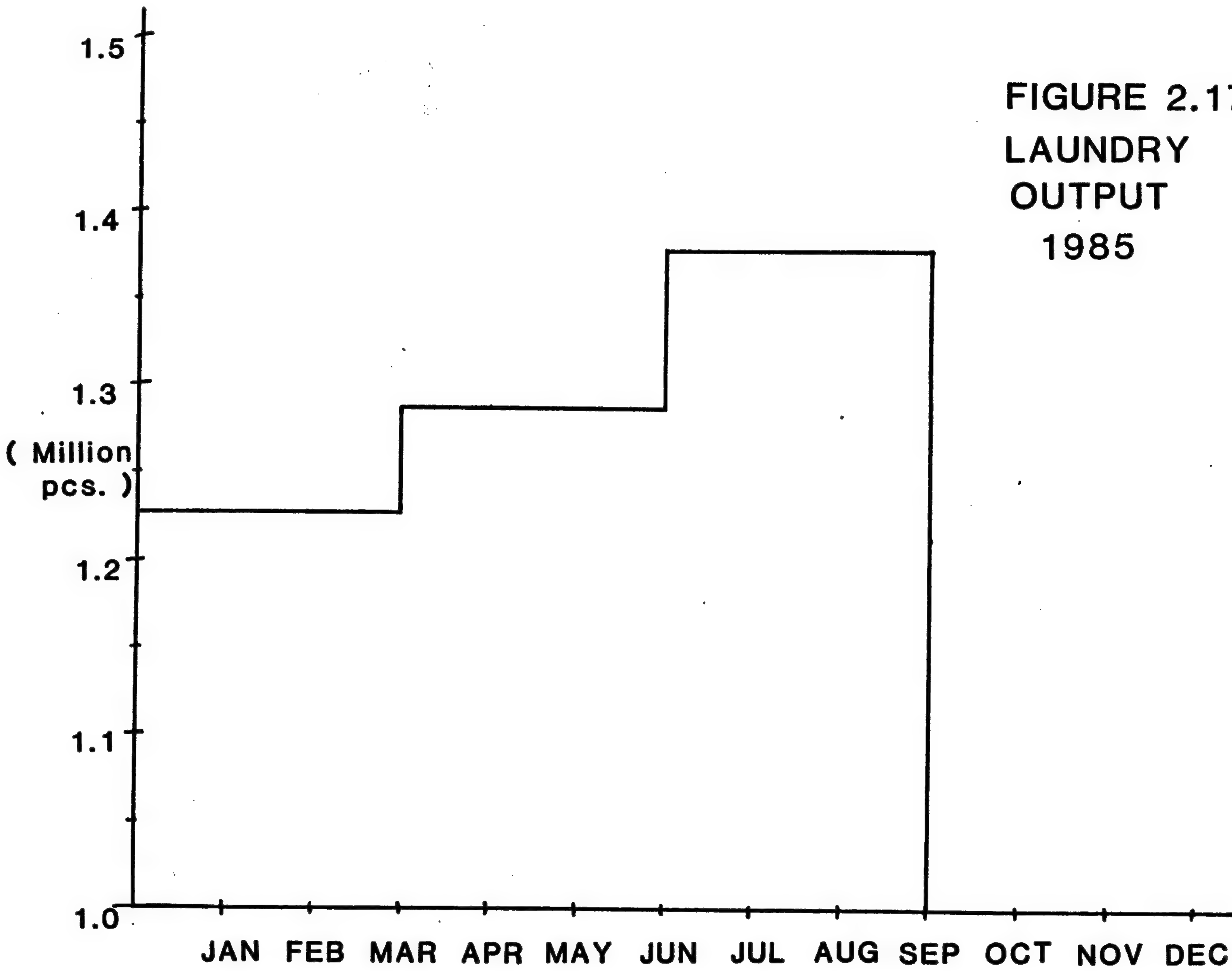


FIGURE 2.16
LAUNDRY OUTPUT
1984

FIGURE 2.17
LAUNDRY
OUTPUT
1985



3.0 ENERGY CONSERVATION OPPORTUNITY (ECO) SELECTION

3.1 Introduction

The objective of this study is to develop ECO's which will reduce energy consumption at the Laundry Facility. Using this list of ECO's, military construction projects are created and funding sources sought. These construction projects generally consist of several energy conservation opportunities logically combined in a manner to form a construction project. Energy conservation opportunities are the individual elements of work which can be performed to save energy. For example, replacing single glazed windows with double glazed windows is an energy conservation opportunity. Adding insulation to an existing roof is another example of an energy conservation opportunity. Those two ECOs might be combined for several buildings to be implemented as part of a single construction project.

One of the first steps is to identify those energy conservation opportunities which will be analyzed as a part of the study. Once those items are identified, their applicability to a particular building must be determined through judgement based on the field survey data. The Scope of Work provides several lists of ECOs which have been successful at similar facilities.

3.2 Creation of Master ECO List

These ECO's were examined for their applicability to this specific site. This list of ECO's is reproduced in matrix form indicating which ECO is applicable to what building. Explanation of why certain ECO's were not evaluated on particular buildings is also included. Refer to Figure 3.1. Using ECO's from the supplied list, supplemented by additional ECO's identified through field survey, a list

of potential ECO's to be evaluated in each building was prepared. This master list of ECO's is subdivided into 3 "Trades": Architectural, Electrical, and Mechanical. A brief explanation of each ECO is continued in the following section.

3.3 ECO Descriptions

3.3.1 Architectural ECO's

A1: Insulate Floor

Buildings T-15 and T-16 have wood framed floors above an unheated crawl space. This ECO provides for the insulation of 6" fiberglass batt insulation under the floor.

A2: Insulate Walls

Buildings T-15, T-16 and T-18 have wood frame walls with 6" wall cavities. To reduce cost and interference with building operation, insulation will be blown into the wall cavities from the exterior. Building T-17 can be insulated by installing rigid board insulation on the inside of the siding. Insulation is then protected by a stucco covering.

A3: Insulate Roof

Insulation of the roof is accomplished in several ways, depending on the building and construction type. In parts of T-15 and T-16, insulation can be blown in above the ceiling. In other areas, a new ceiling with insulation above it must be used. T-17 can be insulated in much the same way as the walls.

A4: Weatherstrip:

To reduce heat loss, infiltration of outdoor air should be reduced. Weatherstripping the perimeter and meeting edges of doors and windows can provide significant savings.

A5: Construct Vestibule

Vestibules are designed to reduce infiltration by limiting the amount of outdoor air that can enter the building when a door is opened. Vestibules for personnel doors consist of a small framed extension of the building at an entry door fitted with its own exterior door. A person must first enter the vestibule, shutting the door behind him, before entering the building proper. Larger vestibules can be constructed at loading docks to reduce infiltration while handling materials.

A6: Double Glaze (Same Size Windows)

This ECO provides for the removal of existing single glazed window units and their replacement with double glazed units of the same size. A minimal amount of framing and finish carpentry is required.

A7: Double Glaze (Reduced Size Windows)

Many of the window units now in place are larger than required. By replacing the existing single glazed units with smaller double glazed units and by filling in the space around these new windows with insulated walls, more energy can be saved.

A8: Install Solar Shading Film

In buildings with large east and west glazed areas, summer solar heat gain can be excessive. Shading films can be installed on existing windows to reduce this heat gain.

A9: Install Plastic on Windows

A lower cost, temporary solution to heat loss through single glazed windows is the installation of plastic film during winter months over single glazed windows. When properly installed, conductive heat loss and infiltration are reduced.

A10: Insulate Upper Windows

The windows of Building T-18 are very large single glazed units. The upper halves of the window units have been painted opaque. Because no light is admitted through this area, insulation can be installed inside the window thereby reducing heat loss.

A11: Repair Underpinning

Building T-15 and T-16 have wood framed floors above an unheated crawl space. Underpinning prevents cold wind from blowing underneath the floor. If a region of still air can be maintained below the floor, heat loss is reduced.

A12: Replace Doors

Buildings T-16 and T-18 are fitted with very loose fitting wood construction doors. Replacement of these doors with new, better fitting, weatherstripped doors can save energy.

A13: Install Door Seals

Building T-18 has large loading doors through which laundry passes. At present, large quantities of outdoor air enter the building while these doors are open. The use of flexible strips and air barriers can reduce this infiltration and improve comfort.

A14: Seal Old Heating Room

Building T-15 contains an abandoned mechanical room with loose fitting doors open to the outdoors. Sealing these doors and outdoor air intake louver will reduce infiltration to the building.

A15: Remove Window Air Conditioners in Winter

Building T-15 uses window air conditioners for comfort cooling during the summer months. By removing these air conditioners and shutting the windows, infiltration can be reduced.

A16: Building Insulated Storage Room

Warehouse T-16 is maintained at a minimum temperature of 50° during the winter to protect stored chemicals from freezing. A small, well insulated, sealed room within the warehouse could be constructed to house the small quantities of temperature sensitive materials and discontinue heat to the rest of the warehouse.

A17: Seal Boiler Outside Air Intake Dampers

Building T-17 is fitted with two large outside air intake louvers designed to provide air for the

boilers. These louvers are oversized and do not seal tightly. Infiltration and heat loss results. These dampers could be sealed with plastic during winter months, and combustion air could be supplied through a smaller duct routed to the vicinity of the burner intake.

A18: Close Gravity Roof Ventilator

Building T-17 is fitted with a gravity roof ventilator to provide ventilation of the boiler plant. This ventilator remains open year round. The ventilator should be repaired and closed during winter months to conserve heat.

A19: Seal Unused Roof Penetrations

Building T-18 has been renovated several times during its 47 year life. As a result, several roof penetrations for equipment once installed are no longer used. Many of these remain open allowing heat to escape throughout the year. They should be sealed to conserve heat in the winter and operable vents and fans used in the summer.

3.3.2 Electrical ECO's

E1: Replace Lighting Fixtures With More Efficient Units

Existing lighting fixtures in each building include incandescent lighting fixtures and old preheat style fluorescent fixtures. Replacement of these fixtures with energy efficient fluorescent units save energy.

E2: Install High Efficiency Fluorescent Lamps

Existing fluorescent fixtures use 40 watt fluorescent tubes. More energy efficient 32 and 36 watt tubes can be utilized.

3.3.3 Mechanical ECO's

M1: Replace Heating System

Existing heating systems using steam unit heaters lack the ability to provide close, accurate control. Control strategies including outside air reset and night setback are difficult to implement effectively. Widely varying loads at the boiler plant and on the existing, marginally effective condensate return system complicate the use of these strategies. Problems with faulty pipe insulation, steam traps and system age contribute to inefficiency.

a) Hot Water Unit Heaters - Existing steam unit heaters and steam piping is replaced with new hot water unit heaters, hot water piping and control systems. Hot water for space heating can be generated by a steam to hot water heat exchanger in Building T-17 or by a separate hot water boiler in T-17.

b) Direct Fired Natural Gas Unit Heaters - Existing steam unit heaters and steam piping is removed. New direct fired natural gas unit heaters, natural gas piping, and controls are installed. No boiler or heat exchanger system is required.

c) Infra-Red Heating

In certain areas, such as loading docks and heated warehouses, where infiltration is high and cannot be reduced because of the nature of the areas' usage, infra-red heating can be effectively used. Infra-red systems warm people and materials directly rather than warming air. Consequently, less heat is lost by air exchange with the outdoors.

M2: Night Setback Control

Install a system of timeclocks, contactors, and override thermostat to reduce the temperature of buildings automatically during unoccupied periods.

M3: Install Central Steam Valve

Building T-18 receives steam from T-17 through a single steam main. Installation of an automatic central steam control valve would isolate the piping of Building T-18 after hours and reduce heat loss through the piping system. This would be particularly useful if another type of heating system is installed.

M4: Install/Repair Condensate Return System

Building T-15 and T-16 receive low pressure steam from T-17. The length of the steam and condensate piping, poor insulation, and common condensate return in T-17 contribute to poor system operation and condensate loss. Installation of a condensate return pump in T-15 and repair of the condensate return system in T-16 would save energy.

M5: Repair Steam Traps

Steam traps are notorious for leaking and causing energy waste. All steam traps require periodic maintenance to insure proper operation. Several traps were observed to be leaking at the time of the field survey.

M6: Insulate Steam Piping

Steam and condensate return piping is uninsulated in places. In other locations, insulation is damaged. Installation of insulation reduces heat loss, improves steam system operation, and provides better control of building heating.

M7: Install Ceiling Fans to Reduce Stratification

In buildings with high ceilings, warm air stratifies. To maintain comfort at floor level where people work, higher thermostat settings must be maintained. The use of ceiling fans provides air circulation, maintains more even temperatures throughout the space and saves energy through reduced thermostat settings. Note this ECO was evaluated but will not be included in project documentation as per TRADOC policy.

M8: Decrease Warehouse Temperature

The warehouse of T-16 is maintained at 50° during the winter to protect stored chemicals from freezing. A lower temperature of 40° could be used while conserving energy. To enable this to be done, new thermostats with a lower minimum setpoint would have to be installed.

M9: Discontinue Warehouse Heat

Building T-16 houses an office, parts storage area, and some temperature sensitive chemicals that require the building to be heated. Relocation of these activities to a renovated area of T-18 would enable the heat to the entire building to be shut off.

M10: Replace Condensate Cooler

The heat exchanger in Building T-17 used to preheat domestic hot water from returned condensate is in poor condition. Its replacement could save a significant amount of energy.

M11: Insulate Condensate Tank

The condensate tank in T-17 is uninsulated which results in system energy waste.

M12: Install Flue Economizer

Boilers exhaust combustion products to a flue at elevated temperatures. Some of this heat can be extracted and used to preheat boiler feedwater resulting in energy savings.

M13: Insulate Flue

The boiler flue in Building T-17 is constructed of uninsulated sheet metal. Much waste heat is released to the interior through the flue. By installing insulation, heat loss is reduced and use of a flue economizer can be more effective.

M14: Calibrate Controls

The existing boiler controls in T-17 function adequately but, as with all controls, require periodic service and calibration. Through proper adjustment, boiler combustion efficiency can be improved.

M15: Install Automatic Blow-Down Controls

The boilers in Building T-17 are manually blown down based on daily water quality tests. While this method is adequate, it wastes steam and hot water. Automatic blow down controls continuously monitor boiler water quality and blow down the boilers only as needed to maintain water quality at a setpoint.

M16: Repair Domestic Hot Water Piping

Steam and condensate piping at domestic hot water converters in Building T-17 leaks and has no insulation. Repair of this piping will save energy and improve plant safety.

M17: Reinsulate Domestic Hot Water Tanks

The domestic hot water tanks in T-17 have insulation damaged by leaks in the piping. Removal of this insulation and installation of new, more effective insulation will reduce tank heat losses.

M18: Install Separate Handwash Domestic Hot Water Source

The laundry facility of building T-18 requires large quantities of high temperature domestic hot water. Water is supplied at 180°F. Hand washing sinks in the restrooms are also supplied from this same

source. Long piping runs to each restroom take a long time to deliver hot water at the tap which, when it arrives, is dangerously hot. Small, under-the-counter, electric water heaters could be used to save energy by delivering 110°F water on demand.

M19: Reduce Wash Temperature

Much of the laundry is washed and rinsed in water of 140°F or more. A reduction in temperature can save large quantities of energy. Hand-in-hand with a reduction in temperature may be an increase in chemicals required to deliver the same level of cleanliness. Testing of temperatures and wash formulas would be required.

M20: Recycle Rinse Water

In some facilities it is possible to use the second or third rinse cycle water for breaking and washing clothing in an adjacent washer. This interconnection saves water and energy.

M21: Install Waste Water Heat Recovery System

Laundries use large quantities of hot water which are generally dumped down a drain at a high temperature. Installation of collecting basins, heat exchangers, pumps and controls allow heat from waste water to be used for preheating domestic hot water.

M22: Install Dryer Heat Recovery System

Dryers exhaust large quantities of hot, moist air. Through the installation of heat exchangers, blowers, and ductwork, this formerly wasted heat could be

utilized to warm other areas of the laundry such as loading dock areas.

M23: Install Improved Dryer Lint Traps

Lint exhausted from dryers is trapped in filters and must be periodically removed. If allowed to accumulate, lint reduces dryer capacity and wastes dryer blower horsepower. New, self-cleaning lint traps can improve dryer system operation efficiency.

M24: Construct Direct Outdoor Air Connections to Dryers

Dryers draw in room air, heat it, pass it across clothing to extract moisture and exhaust this moist air to the outside. This room air drawn in was previously heated by the building heating system. Its exhaust requires outdoor air to be drawn into the building causing uncomfortable drafts at the building perimeter. Direct duct connections of outdoor air to the dryers minimize these effects.

M25: Replace Old Dryers

Eleven existing dryers in Building T-18 are old and are in need of replacement. New, energy efficient dryers with moisture sensors to control drying time can save energy.

M26: Replace Flatwork Ironers with New Thermal Fluid Units

While the existing flatwork ironers work adequately well, they were designed for 125 psig steam input. They are run at 100 psig steam pressure and consequently must run at a lower speed. New thermal fluid heated ironers run at higher temperatures and higher

production speeds. Thermal fluid systems also do not require boiler operators and hold potential for labor and maintenance savings.

M27: Install Intercooler on Air Compressor

The use of an intercooler between compression stages of large air compressors can reduce the amount of energy required to perform the same task.

M28: Clean Unit Heater Coils

The steam heating coils of unit heaters in the laundry have accumulated lint and dirt which decreases heat transfer efficiency. Cleaning these coils improves heater effectiveness.

M29: Repair Steam Leaks

Several of the machines have small steam leaks through couplings and control valves. During winter nights when the laundry equipment is not in operation, but steam pressure is up for space heating, steam is lost.

M30: Repair Compressed Air Leaks

Compressed air leaks on machinery causes the air compressor to operate for longer periods of time during morning start-up and breaks while laundry equipment is idle.

M31: Increase Condensate System Pressure

The condensate return system in Building T-17 is currently vented to the atmosphere. System

modifications which will enable the condensate system to be pressurized to 5 psig can result in energy savings through decreased flash steam loss.

M32: Install Heat Exchanger on Steam Feedwater Pump

The steam driven feedwater pump exhausts steam to the feed water heater and any excess steam is vented to the atmosphere. A heat exchanger could capture this waste heat to preheat domestic hot water.

M33: Replace Steam Driven Feedwater Pumps with Electric Feedwater Pumps

The existing boiler plant uses two steam driven positive displacement pumps to deliver feedwater to the boiler. Electric driven pumps could be installed to provide the same service more efficiently.

3.4 ECO Matrix

A matrix indicating which ECO's were analyzed in each building was prepared and is contained in Figure 3.2. Additional detailed information on quantities, types, and applications of materials to implement each ECO is contained in Appendix B of the Energy Study.

3.5 Other Projects Underway

During the field survey, information on planned and funded projects for the facility was requested. Personnel at Fort Knox indicated that there are no projects under construction, funded and awaiting the start of construction, or in the planning stages for the Laundry Facility.

3.6 EEAP Study

In March 1983, an Energy Engineering Analysis Program for the entire Fort Knox installation was completed. As part of this study, the Boiler Plant, T-17, and the Laundry, Building T-18, were analyzed. The study evaluated the use of shallow solar ponds for domestic water heating. However, neither of the two configurations had benefit to cost ratios greater than 1.0 and thus the ECO's were not developed into projects for funding.

Two Increment F projects for the Boiler Plant, T-17, were identified. These projects fall into the category of low cost, maintenance related work that can be accomplished by installation personnel using installation funds. Neither of the projects, Installation of Turbulators for Fire Tube Boilers and Installation of a Boiler Feedwater Economizer, have been implemented.

Findings and results of the EEAP Study were reviewed during the field survey portion of this study. While this information was taken into account when selecting potential ECO's for analysis, detailed analysis of the Laundry Facility's physical plant, operation, energy consumption and potential for energy savings was performed independently.

Figure 3.1

MATRIX OF RECOMMENDED ECO's FROM ANNEX A

OF PROJECT SCOPE OF WORK

ECO	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
Insulate	X	X	X	X	
Storm Windows/Double Glaze	X	X		X	A
Weatherstrip, Caulk	X	X	X	X	
Insulated Panels				X	B
Solar Films	X			X	C
Vestibules	X	X		X	D
Reduction of Glass Area	X	X		X	A
Shutdown Hot Water Heaters					E
Energy Conserving Fluor. Lamps	X	X			F
Reduce Lighting Levels					G
Replace Incand. Lighting	X	X	X	X	
Use More Efficient Lighting	X	X	X	X	
Night Setback/Setup	X	X		X	H
Infra-Red Heaters				X	I

Figure 3.1

MATRIX OF RECOMMENDED ECO's FROM ANNEX A

OF PROJECT SCOPE OF WORK

ECO	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
Economizer Cycles					J
Heat Reclaim - Laundry				X	K
Insulate Piping	X	X	X	X	
Heat Destratification	X	X	X	X	L
Heat Recovery - Wash Water				X	K
Booster Heaters for Hot Water					E
Lower Domestic Hot Water Temp				X	E
Upgrade HVAC Controls	X	X	X	X	
Steam Trap Repair	X	X	X	X	
Improve HVAC System Efficiency	X	X	X	X	
Improve Laundry System Efficiency				X	K
Optimize Laundry Facility Operation				X	K
Balance HVAC System					J
Change to VAV System					J

Figure 3.1

MATRIX OF RECOMMENDED ECO's FROM ANNEX A

OF PROJECT SCOPE OF WORK

ECO	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
Use Air Curtains, Strip Doors				X	M
Dryers with Efficient Controls				X	K
Recycle Rinse Water					N
Dryer Heat Exchangers				X	K
Modify Steam & Condensate System	X	X	X	X	
Utilize Thermal Fluid Machine				X	K
Use Heat Pump Water Heaters					E
Use Cold Water for Laundry				X	K
Waste Heat Recovery			X	X	K
Check Air Compressor				X	K
Increase Boiler Efficiency			X		O
Repair Condensate System			X		O
Insulate Boiler & Piping			X		O
Install Economizer			X		O

Figure 3.1

MATRIX OF RECOMMENDED ECO's FROM ANNEX A

OF PROJECT SCOPE OF WORK

ECO	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
Install Air Preheater				O,	P
Check Boiler Chemistry		X		O	
Clean Boiler Tubes				Q	
Blow Down Controls		X		O	
Boiler Control Modifications		X		O	
Water Treatment				O,	R
Replace Boilers				O,	S

NOTES

A. Building T-17 is a Boiler Plant. While the building has a few large windows, heat loss through them is a small portion of the total heating load. Furthermore, the building is largely warmed by uncontrolled heat loss from the boiler equipment.

B. Insulated panels for use on building windows are not practical in these buildings. Small window areas are relied upon for the admission of daylight.

C. Solar films are used to reduce summer solar heat gain. They have little benefit in buildings that are not air conditioned or have small east and west glazed areas.

D. Vestibules are not appropriate for installation on the Boiler Plant. The large double door must be maintained for equipment access. The other personnel door is used infrequently.

E. Buildings T-15, T-16, and T-17 have no domestic hot water systems. Building T-18 uses very large quantities of high temperature hot water. It is a required process load.

F. Buildings T-17 and T-18 use incandescent lighting almost exclusively. These incandescent fixtures should be replaced.

G. Field survey indicates that all areas of the facility have very low light levels and should not be further reduced.

H. Building T-17 is heated only while the building is in use.

I. Infra-red heating systems are not appropriate for use in office/classroom spaces of Buildings T-15, T-16. Heat in Building T-17 is used primarily for freeze protection for which infra-red heating would be less effective.

J. Buildings do not have central HVAC systems.

K. Buildings T-15, T-16, and T-17 do not contain laundry equipment.

L. Low ceiling height of T-16 makes destratification ineffective. Destratification is not desirable in the Boiler Plant.

M. Vestibules evaluated on Buildings T-15 and T-16. See also D.

N. Water and drain connections on washers make connections impractical.

O. Buildings T-15, T-16, and T-18 have no boilers. The central boiler is located in T-17.

P. Existing boilers cannot be retrofitted with preheat system cost effectively.

Q. Tubes are regularly cleaned.

R. Water treatment system now in use.

S. Existing boilers are in good condition.

Figure 3.2

MATRIX OF ECO's

EVALUATED IN EACH BUILDING

ECO Number	Description	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
A1	Insulate Floor	X	X			
A2	Insulate Walls	X	X	X	X	
A3	Insulate Roof	X	X	X	X	
A4	Weatherstrip	X	X	X	X	
A5	Construct Vestibule	X	X		X	
A6	Double Glaze (Same)	X	X		X	
A7	Double Glaze (Reduced)	X	X		X	
A8	Solar Shading Film	X			X	
A9	Install Plastic Film	X				
A10	Insulate Upper Window				X	
A11	Repair Underpinning	X	X			
A12	Replace Doors		X		X	
A13	Install Door Seals				X	
A14	Seal Old Heating Room	X				
A15	Remove Window A.C.	X				

Figure 3.2

MATRIX OF ECO's

EVALUATED IN EACH BUILDING

ECO Number	Description	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
A16	Build Insulated Storage		X			
A17	Seal O.A. Intake			X		
A18	Close Roof Ventilator			X		
A19	Seal Roof Penetrations				X	
E1	Replace Light Fixtures	X	X	X	X	
E2	Replace Lamps	X	X			
M1	Replace Heating System					
	a) HW Unit Heaters	X	X	X	X	
	b) Natural Gas Unit Heaters	X	X		X	
	c) Infra-Red Heaters				X	
M2	Night Setback Control	X	X		X	
M3	Central Steam Valve				X	
M4	Condensate Return	X	X			
M5	Repair Steam Trap	X		X		

Figure 3.2

MATRIX OF ECO's

EVALUATED IN EACH BUILDING

ECO Number	Description	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
M6	Insulate Steam Pipe	X	X	X		
M7	Install Ceiling Fans	X			X	
M8	Decrease WHSE Temp		X			
M9	Discontinue WHSE Heat		X			
M10	Replace Condensate Cooler			X		
M11	Insulate Condensate Tank			X		
M12	Install Flue Economizer			X		
M13	Insulate Flue			X		
M14	Calibrate Controls			X		
M15	Install Blow-Down Controls			X		
M16	Repair DHW Piping			X		
M17	Reinsulate DHW Tanks			X		
M18	Separate DHW Source				X	
M19	Reduce Wash Temperature				X	

Figure 3.2

MATRIX OF ECO's

EVALUATED IN EACH BUILDING

ECO Number	Description	T-15, DRIVERS ED.	T-16, WAREHOUSE	T-17, BOILER PLANT	T-18, LAUNDRY	NOTES
M20	Recycle Rinse Water				X	
M21	Install Water Heat Recovery			X	X	
M22	Install Dryer Heat Recovery				X	
M23	Install Lint Traps				X	
M24	Dryer O.A. Connection				X	
M25	Replace Old Dryers				X	
M26	Replace Flatwork Ironers				X	
M27	Repair Air Leaks				X	
M28	Clean Unit Heaters				X	
M29	Repair Steam Leaks				X	
M30	Install Air Comp. Intercooler				X	
M31	Pressurize Condensate Return			X		
M32	Install Feed Water Pump Heat Exchanger			X		
M33	Replace Feed Water Pumps			X		

4.0 PROJECT DEVELOPMENT

4.1 Introduction

Once the ECOs were selected for each building (see Section 3.0), the next step in the process was calculation of the savings which would result from and the cost to implement each ECO in each building. The savings from various ECOs have been calculated using a combination of manual and computerized analysis techniques. Detailed descriptions of the methodology used, sample calculations, and results are contained in the Energy Study Report and its Appendices.

Estimated costs have been calculated based on the extent of work in each building. Unit prices used in the estimate were obtained from equipment suppliers and Means Cost Estimating Guide and include Contractor overhead and markup. All construction cost estimates are in FY86 dollars. The detailed cost calculations are provided in Appendix B of the Energy Study Report.

This savings and cost data for each ECO was used to compute economic parameters to determine the viability of a particular project. This economic analysis has been performed in accordance with ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) GUIDANCE dated 15 February 1985, which was furnished as criteria for this study. That ECIP guidance requires the computation of a number of economic measures. These include:

1. ECO construction cost (Dollars)

2. Total annual energy savings (MBTU's)

3. Annual cost savings ($)

4. Total discounted cost savings ($)

5. Discounted savings/investment ratio (SIR)

4.2 ECO's Selected for Implementation

Having performed the economic analysis, ECO's not meeting the minimum economic criteria of savings/investment ratio (SIR) greater than 1.0 were dropped. Qualifying ECO's were grouped to form three projects for funding. They include one ECIP and two PECIP projects.

In addition, remaining ECO's with good savings to investment ratios that did not qualify for funding under QRIP, PECIP, OSD-PIF, or ECIP were identified. Many of these ECO's are of low cost and could be implemented using local funds and personnel. Refer to Tables 4.1 and 4.2 for a summary of these ECO's.

A description of the process used for project grouping is contained in Section 6.0 of the Energy Study Report.

4.2.1 ECIP Project

This project includes the relocation of offices and temperature sensitive materials from Building T-16 to renovated space within Building T-18. Heat to Building T-16 can thereby be discontinued. Additional work includes the demolition of existing steam heating systems and heating distribution pipes in Buildings T-15, T-17, and T-18, installation of new hot water heating systems, distribution piping and controls in each building, and the installation of a new automatic central hot water boiler in Building T-17 to provide heating for Buildings T-15, T-17, and T-18 independent of the existing high pressure process steam boilers in T-17. This ECIP project is

composed of several separate ECO's. These ECO's which include HVAC system modifications were evaluated in accordance with the ECIP guidance using a 15 year economic life. The entire ECIP project, which includes modifications to the center boiler plant, is evaluated using a 25 year life. Refer to Table 4.3 for summary information.

4.2.2 Architectural PECIP Project

This project provides funding for the implementation of architectural ECO's including insulation and weatherstripping in Building T-15, weatherstripping and sealing of Building T-17, and sealing of roof penetrations and window insulation for Building T-18. To qualify for PECIP funding, the project must have a cost of less than $100,000 and an amortization period of less than 4 years. Refer to Table 4.4 for summaries of the ECO's included.

4.2.3 Mechanical PECIP Project

This PECIP project includes funding for the repair of steam traps, domestic hot water piping, a reduction of wash temperatures, and construction of a waste water heat recovery system for Building T-18. See Table 4.5 for a summary of these ECO's.

TABLE 4.1 MISCELLANEOUS ARCHITECTURAL ECO's

BLDG. NO.	ECO NO.	ECO DESCRIPTION	TOTAL COST ($)	TOTAL ENERGY SAVINGS (MBTU)	SIMPLE PAYBACK PERIOD (YEARS)	FIRST YEAR SAVINGS ($)	TOTAL DISCOUNT SAVINGS ($)	SIR
T-15	A-3	INSULATE ROOF	21657	425.4	12.3	1767	38013	1.950
T-15	A-4	WEATHERSTRIP	6819	78.6	20.8	327	7082	1.154
T-15	A-7	DBL. GLAZE (REDUCED AREA)	12149	155.2	18.9	643	13742	1.257
T-15	A-13	SEAL OLD HEATING ROOM	579	12.3	11.3	51	1109	2.129
T-15	A-15	REMOVE WINDOW A.C.	379	5.3	17.2	22	475	1.391
		TOTALS	41583	676.8		2811	60421	

TABLE 4.2 MISCELLANEOUS MECHANICAL ECO's

BLDG. NO.	ECO NO.	ECO DESCRIPTION	TOTAL COST ($)	TOTAL ENERGY SAVINGS (MBTU)	SIMPLE PAYBACK PERIOD (YEARS)	FIRST YEAR SAVINGS ($)	TOTAL DISCOUNT. SAVINGS ($)	SIR
T-17	M-11	INSULATE CONDENSATE TANK	4734	137.2	8.1	582	8462	1.986
T-17	M-14	CALIBRATE CONTROLS	6690	241.4	8.8	757	12452	2.068
T-17	M-33	REPL. FEEDWATER PUMPS	16725	22.1	47.0	356	22800	1.515
		TOTALS	28149	400.7		1695	43714	

TABLE 4.3 ECIP PROJECT SUMMARY

BLDG. NO.	ECO NO.	ECO DESCRIPTION	TOTAL COST ($)	TOTAL ENERGY SAVINGS (MBTU)	SIMPLE PAYBACK PERIOD (YEARS)	FIRST YEAR SAVINGS ($)	TOTAL DISCOUNT. SAVINGS ($)	SIR
T-15, 17,18	M-1a	CHANGE TO H.W. HEAT WITH HW BLR, DISC. HT T-16	402975	3178.6	13.6	29706	449878	1.378

TABLE 4.4 ARCHITECTURAL PECIP PROJECT # 1 SUMMARY

BLDG. NO.	ECO NO.	ECO DESCRIPTION	TOTAL COST ($)	TOTAL ENERGY SAVINGS (MBTU)	SIMPLE PAYBACK PERIOD (YEARS)	FIRST YEAR SAVINGS ($)	TOTAL DISCOUNT SAVINGS ($)	SIR
T-15	A-1	INSULATE FLOOR	9282	284.2	7.9	1182	25504	3.053
T-15	A-2	INSULATE WALLS	5770	384.8	3.6	1601	34549	6.653
T-15	A-9	ADD PLASTIC ON WINDOWS	580	64.6	2.2	267	5692	10.908
T-15	A-11	REPAIR UNDERPINNING	346	67.6	1.2	282	6150	19.769
T-17	A-4	SEAL BUILDING	6961	210.6	8.1	861	17707	2.826
T-17	A-18	CLOSE ROOF VENTILATORS	404	337.7	0.3	1427	32387	89.156
T-18	A-10	INSULATE WINDOW TOP HALF	6602	359.7	4.4	1488	31610	5.320
T-18	A-19	SEAL ROOF PENETRATIONS	1115	347.2	0.8	1472	33358	33.242
		TOTALS	31059	2056.4	3.6	8580	186957	6.69

TABLE 4.5 MECHANICAL PECIP PROJECT # 2

BLDG. NO.	ECO NO.	ECO DESCRIPTION	TOTAL COST ($)	TOTAL ENERGY SAVINGS (MBTU)	SIMPLE PAYBACK PERIOD (YEARS)	FIRST YEAR SAVINGS ($)	TOTAL DISCOUNT SAVINGS ($)	SIR
T-15	M-5	REPAIR STEAM TRAP	453	78.5	1.4	333	4845	11.891
T-17	M-5	REPAIR STEAM TRAP	1338	177.5	1.8	753	10950	9.093
T-17	M-16	REPAIR DOM H. WATER PIPE	7924	293.7	6.4	1245	18119	2.541
T-18	M-19	REDUCE WASH TEMP 5 DEG.	3047	434.9	1.7	1844	26830	9.783
T-18	M-21	WASTE WATER HEAT RECOVERY	32363	1659.6	4.6	7037	102384	3.515
T-18	M-29	REPAIR STEAM LEAKS	914	48.8	4.4	207	3011	3.659
		TOTALS	46039	2693.0	4.03	11418	166138	4.01

At the time of the Final Submittal, repairs had been completed on the domestic hot water piping (ECO M-16). Additional operational changes including the use of cold water wash formulas are being considered which may adversely affect ECO's M-19 and M-21.

5.0 PROJECT IMPACT

5.1 Introduction:

The ultimate goal of this Energy Study is to conserve energy and save money. It is easy to loose sight of this goal, however, and get lost in the reams of paper and millions of calculations that compose the supporting documentation of this Study.

In the following sections, energy savings and first year dollar savings associated with each project developed are summarized by type of fuel. Additionally, calculated energy consumption by type of end use for each building before and after implementation of the projects is presented.

5.2 ECO's Evaluated

A total of 94 ECO's were evaluated in the four project buildings. These ECO's encompass energy conservation work in mechanical, electrical, and architectural trades. These ECO's represent $4.30 million in construction projects that can produce an estimated 22,444 million BTU energy savings worth $94,360 annually in fuel savings. Unfortunately, while all ECO's evaluated produce energy savings, only 34 ECO's have a Savings to Investment Ratio (SIR) greater than 1.0. (Refer to Section 6.0 of the Energy Report). From these 34 qualifying ECO's, 23 were selected for implementation in 5 projects as described in Section 4.0 of this Summary. These 23 ECO's represent a total construction cost of $549,805, produce an energy saving of 9,005.5 million BTU annually and an annual dollar savings of $54,209 (energy and non-energy savings). The other 11 qualifying ECO's not selected are ECO"s that are mutually exclusive to ECO's selected. (For example,

by implementing the ECO to discontinue the heating of Building T-16, all other ECO's for that building were dropped).

As discussed in Section 4.0 of this report these qualifying ECO's were grouped into 5 projects. Energy Savings and first year dollar savings for each of these 5 projects are summarized in Table 5.1.

Table 5.2 lists existing energy budgets for each building and energy budgets for each building after the implementation of all qualifying ECO's. The existing energy budgets for each building were calculated using the "base run" computer models developed for each building and from utility and boiler plant logs obtained from the facility. Final energy budgets were calculated using a revised computer model that incorporates all of the ECO's included in the 5 projects. The total energy reduction in each building reflected by these energy budgets is less than the sum of energy savings for each ECO taken individually. This difference is a consequence of the interrelation of ECO's. For example, less energy can be saved through heating system modifications on an insulated building than the same uninsulated building because less total energy is consumed. Refer to Figures 5.3 through 5.6 for graphic representations of energy savings resulting from the implementation of qualifying ECO's in each building.

5.3 Conclusion

Even a cursory inspection of the Laundry Facility identifies many traditionally cost effective ECO's. The temporary buildings, built in 1939, lack insulation, double glazing, and efficient lighting systems. Loose fitting doors and windows also suggest potential areas for savings.

Analysis of these and other ECO's verifies that energy saving potential exists. However, the comparatively low cost of energy at Fort Knox and somewhat higher costs incurred to retrofit an existing, occupied building render these ECO's uneconomic.

Several ECO's involving the replacement of equipment with more energy efficient models were investigated. The high first cost of this machinery again makes these ECO's uneconomic.

The results of this study suggest that the low/no cost ECO's identified should be implemented immediately. Other cost effective ECO's should be funded through projects created by this study. Long range planning should be directed toward the ultimate replacement of the Laundry Facility. At such a time, many of the ECO's identified under this study as uneconomic for retrofit application, should be incorporated into the design of the new facility.

TABLE 5.1

Project Annual Savings

PROJECT	ENERGY TYPE	ENERGY SAVINGS (MBTU/YR)	COST SAVINGS ($)
Miscellaneous	Nat. Gas	594.5	$ 2,521
Architectural	Elect.	82.3	290
ECO's	Non-Energy	0	0
	Total	676.8	$ 2,811
Miscellaneous	Nat. Gas	770.3	$ 3,266
Mechanical	Elect.	-369.6	- 1,305
ECO's	Non-Energy	0	-267
	Total	400.7	$ 1,694
ECIP	Nat. Gas	3178.6	$13,475
Project	Elect.	0	0
	Non-Energy	0	16,231
	Total	3178.6	$29,706
Architectural	Nat. Gas	1867.7	$ 7,919
PECIP	Elect.	188.7	666
Project	Non-Energy	0	-5
	Total	2056.4	$ 8,580
Mechanical	Nat. Gas	2693.0	$11,418
PECIP	Elect.	0	0
Project	Non-Energy	0	0
	Total	2693.0	$11,418
Total	Nat. Gas	9104.1	$38,599
All Projects	Elect.	- 98.6	- 349
	Non-Energy	0	15,959
	Total	9005.5	$54,209

TABLE 5.2

Building Energy Budgets

T-15 Driver's Education Building

	Existing	After ECO's
Heating	825.4×10^6 BTU/YR	167.4×10^6 BTU/YR
Auxiliary	182.1×10^6 BTU/YR	132.6×10^6 BTU/YR
Lights & Equip	115.0×10^6 BTU/YR	200.9×10^6 BTU/YR
TOTAL	1.123×10^9 BTU/YR	500.9×10^6 BTU/YR

T-16 Warehouse

	Existing	After ECO's
Heating	774.5×10^6 BTU/YR	0
Auxiliary	140.1×10^6 BTU/YR	0
Lights & Equip	56.85×10^6 BTU/YR	56.85×10^6 BTU/YR
TOTAL	971.5×10^6 BTU/YR	56.85×10^6 BTU/YR

T-17 Boiler Plant

	Existing	After ECO's
Heating	637.7×10^6 BTU/YR	362.4×10^6 BTU/YR
Auxiliary	205.8×10^6 BTU/YR	113.5×10^6 BTU/YR
Lights & Equip	500.1×10^6 BTU/YR	178.7×10^6 BTU/YR
TOTAL	1.344×10^9 BTU/YR	654.6×10^6 BTU/YR

TABLE 5.2 (continued)

Building Energy Budgets

T-18 Laundry

	Existing	After ECO's
Heating	2.379×10^9 BTU/YR	1.132×10^9 BTU/YR
Auxiliary	692.9×10^6 BTU/YR	247.0×10^6 BTU/YR
Lights & Equip	876.2×10^6 BTU/YR	876.2×10^6 BTU/YR
Domestic Hot Wtr	6.089×10^9 BTU/YR	3.701×10^9 BTU/YR
Process Heating	11.01×10^9 BTU/YR	9.932×10^9 BTU/YR
Process Electricity	3.435×10^9 BTU/YR	3.435×10^9 BTU/YR
TOTAL	24.48×10^9 BTU/YR	19.32×10^9 BTU/YR

FIGURE 5.3
BUILDING T-15
ENERGY BUDGETS

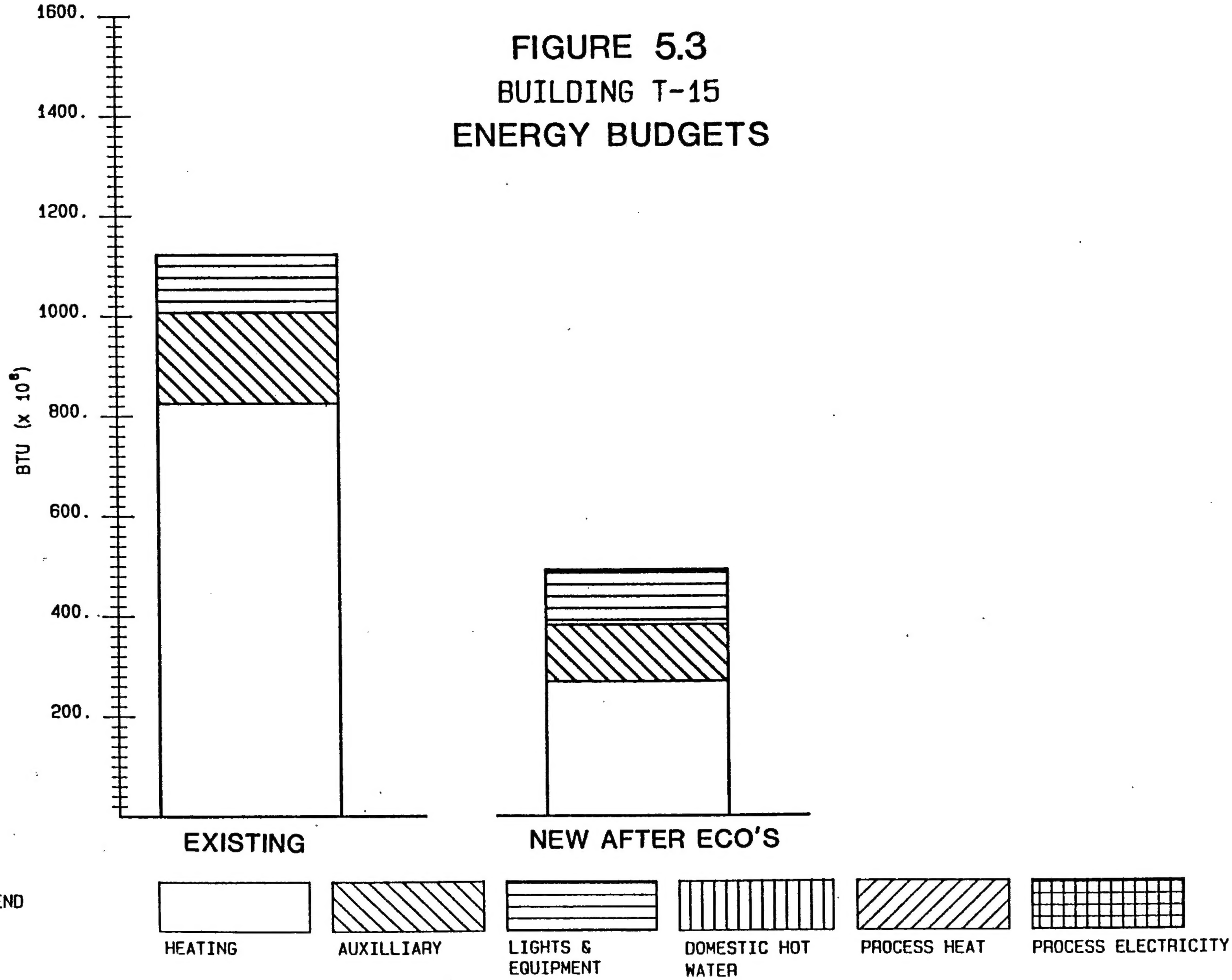


FIGURE 5.4
BUILDING T-16
ENERGY BUDGETS

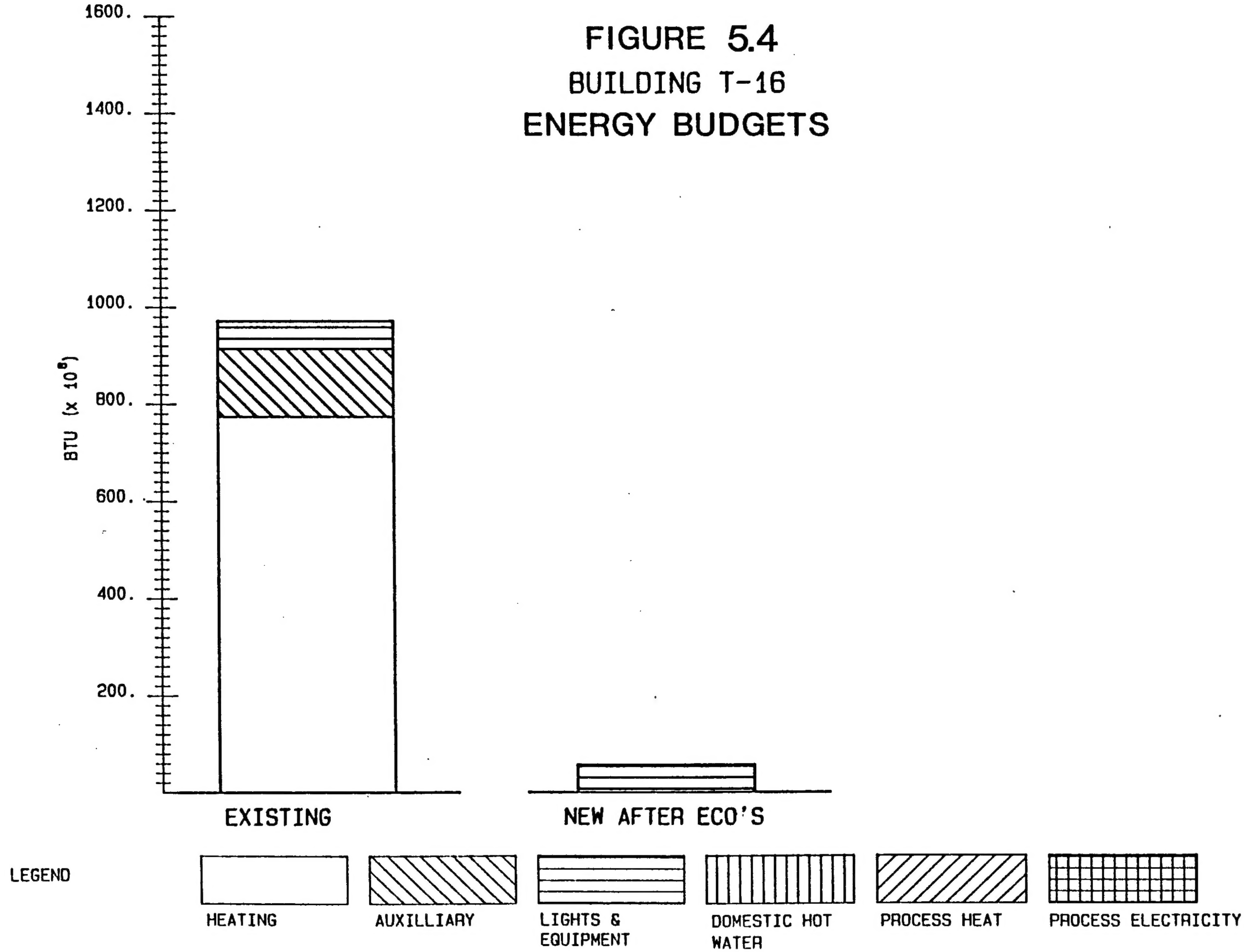


FIGURE 5.5
BUILDING T-17
ENERGY BUDGETS

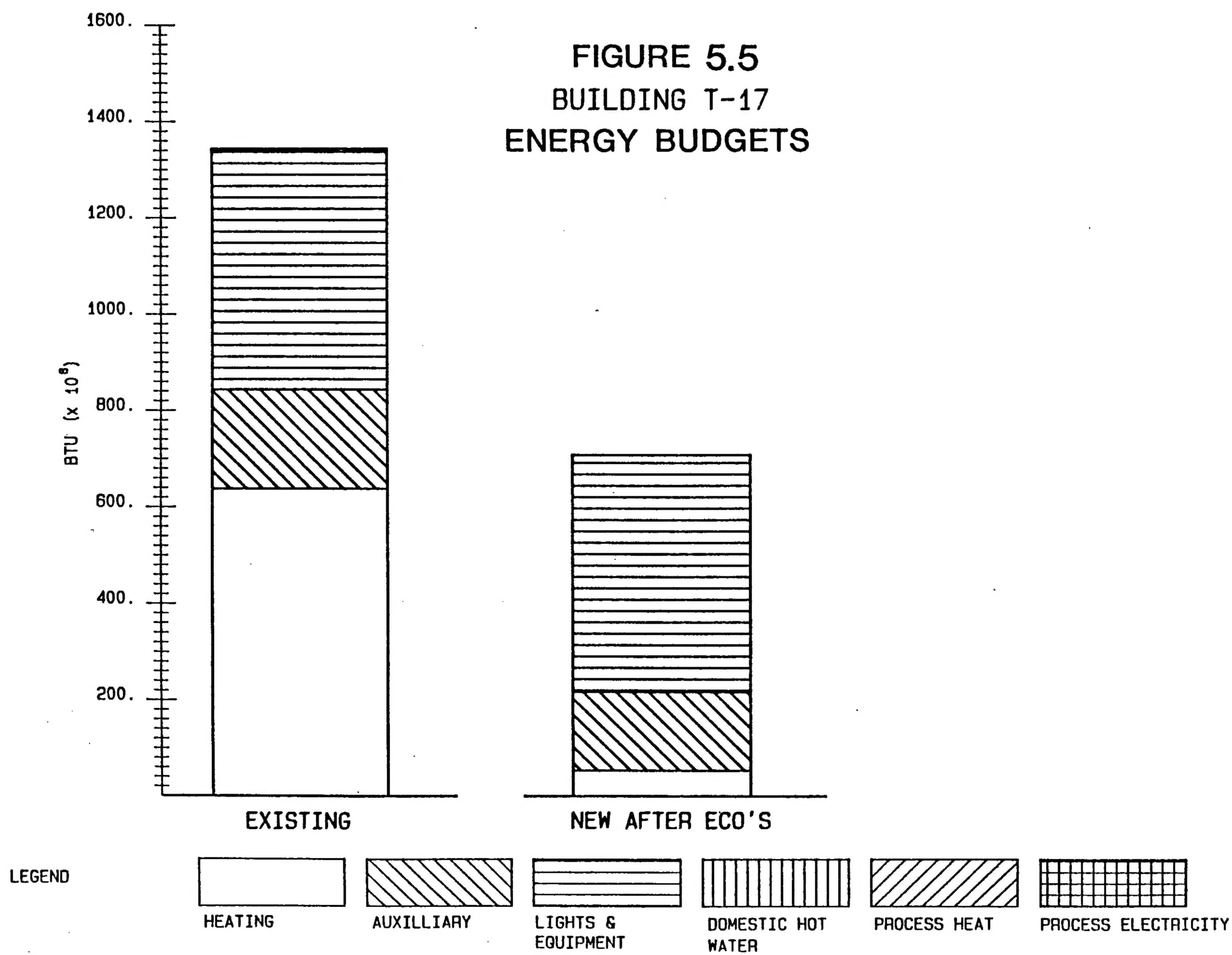


FIGURE 5.6
BUILDING T-18
ENERGY BUDGETS